ISBN No. 978-81-971265-5-0

GOLDEN JUBILEE 1971-2020

ALL INDIA COORDINATED RESEARCH PROJECT ON POULTRY BREEDING

50 Years of Successful Journey

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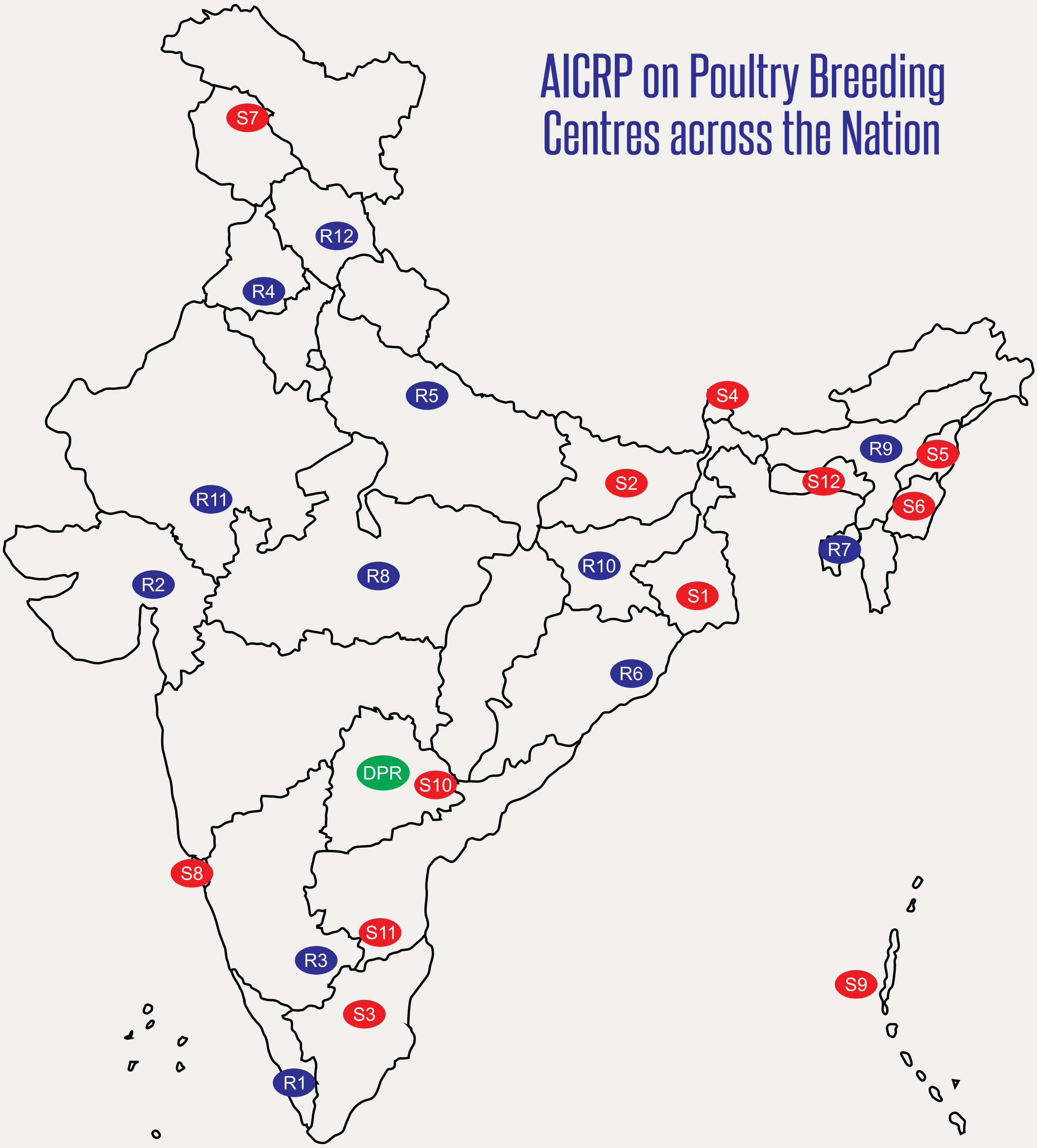
ICAR-DIRECTORATE OF POULTRY RESEARCH

ISO 9001-2015

AICRP on Poultry Breeding Centres across the Nation



ICAR - DPR

AICRP Centres (old)	
R1	KVASU, Mannuthy
R2	AAU, Anand
R3	KVAFSU,Bengaluru
R4	GADVASU, Ludhiana
R5	ICAR-CARI, Izatnagar
R6	OUAT, Bhubaneswar
R7	ICAR-RCNEH, Agartala
R8	NDVSU, Jabalpur
R9	AAU, Guwahati
R10	BAU, Ranchi
R11	MPUAT, Udaipur
R12	CSKHPKVV, Palampur

AICRP Centres (2023 onwards) Former PSP Centres	
S1	WBUAFS, Kolkata
S2	BASU, Patna
S3	TANUVAS, Hosur
S4	ICAR-RCNEH, Gangtok
S5	ICAR-RCNEH, Jharnapani
S6	ICAR-RCNEH, Imphal
S7	SKUAST, Srinagar
S8	ICAR-CCARI, Goa
S9	ICAR-CIARI, Port Blair
S10	PVNRTVU, Warangal
S11	SVVU, Tirupati
S12	ICAR-RC for NEHR, Barapani

50 Years

All India Coordinated Research Project on Poultry Breeding

50 Years of Successful Journey

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ICAR-Directorate of Poultry Research

ISO 9001:2015

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https://aicrp.icar.gov.in/poultry

ISBN No. 978-81-971265-5-0

Citation:

Rajkumar, U, R N Chatterjee, Santosh Haunshi, L Leslie Leo Prince and Aneet Kour. 2024. AICRP on Poultry Breeding-50 Years of Successful Journey, pp 204.

Published by:

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DPR Publications - 02/2024

Designed & Printed at:
Spoorthi Printers Pvt. Ltd.
Lakdi-ka-pul, Hyderabad, Telangana - 500 004

Preface

All India Coordinated Research Project (AICRP) on Poultry Breeding had its modest beginning in the year 1970-71 with the objective to produce superior genetic stocks of layers and broilers and to encourage self-reliance in poultry production. AICRP has been a major force in shaping the countries research progress in poultry production and this was widely acknowledged with the Sardar Patel ICAR Outstanding Institution Award bagged by the institute in 2014. As we celebrate the Golden Jubilee of AICRP, we look back at the journey and take pride in the achievements and contribution of AICRP in country's poultry history. I present, the Golden Jubilee Publication (1971-2020) highlighting the significant achievements and successful journey of the project in the form of book.

Mandate of AICRP on Poultry breeding was initially aimed at developing high yielding layer and broiler strains for commercial poultry. This had a resounding success with development of seven high yielding layer and broiler varieties for commercial exploitation and encouraged and attracted the farmers to poultry farming. However, depending on the changing need and demands of the time, the mandate was subsequently reoriented towards rural poultry development and major emphasis was laid on the promotion and propagation of rural poultry as a tool for nutritional and livelihood security in rural and tribal areas of the country. Also, with the renewed push for conserving indigenous genetic resources, conservation, improvement, characterization and application of local native germplasm was added as one of the objectives. This meant that rather than a blanket approach of propagating the same varieties throughout the country, a special focus was made on the development of location-specific chicken suited to different agroclimatic regions. Accordingly, location-specific chicken varieties viz., *Pratapdhan, Narmadanidhi, Kamrupa, Jharsim, Himsamridhi, Tokbari* have been developed by different AICRP centres which are being popularized in their respective regions.

This year, the golden jubilee of AICRP is also coinciding with another landmark achievement the total germplasm supply across the country crossed the milestone of 1.36 crores. I dedicate this moment of great pride to the relentless perseverance, hard work and unflinching attitude of all the staff of AICRP centres and ICAR-DPR, Hyderabad. I also express my heartfelt gratitude to Dr. Himanshu Pathak, Secretary, DARE and Director General, ICAR whose constant support and encouragement has greatly helped the poultry sector. I am grateful to Dr. Raghavendra Bhatta, Deputy Director General (AS) and Dr. J.K. Jena, Former, Deputy Director General (AS) and all the former DDGs for their valuable guidance and advice. Special thanks are due to Secretary, ICAR and Financial Advisor, ICAR for their unequivocal help and immense cooperation. Dr. G.K. Gaur, Assistant Director General (AP&B) and all the former ADGs deserve special mention for their unwavering help, warm support and guidance. I express my heartfelt appreciation for all the scientists of AICRP cell at the institute and the PIs of different AICRP centres for toiling hard and contributing in the growth and development of poultry sector. The entire editorial board deserves a special appreciation for meticulously tracing the journey of AICRP on Poultry Breeding in this golden jubilee edition.

Date: 16-04-2024

(R.N. Chatterjee)
Director

Abbreviations

AFE	Age at first egg
ASM	Age at sexual maturity in days
BA	Breast Angle
BW0	Body Weiht at 0 day
BW2	Body weight at 2 weeks of age
BW4	Body weight at 4 weeks of age
BW6	Body weight at 6 weeks of age
BW16	Body weight at 16 weeks of age
BW20	Body weight at 20 weeks of age
BW40	Body weight at 40 weeks of age
BW64	Body weight at 64 weeks of age
BW72	Body weight at 72 weeks of age
EP40	Egg production number up to 40 weeks of age
EP64	Egg production number up to 64 weeks of age
EP72	Egg production number up to 72 weeks of age
EW28	Egg weight at 28 weeks of age
EW40	Egg weight at 40 week of age
EW64	Egg weight at 64 weeks of age
EW72	Egg weight at 72 weeks of age
FCR	Feed conversion ratio
FES	Fertile eggs set
Gen.	Generation
HHEP	Hen housed egg production
HDEP	Hen day egg production
KL6	Keel length at 6 weeks of age
SEP	Survivors' egg production
SL4	Shank length at 4 weeks of age
SL6	Shank length at 6 weeks of age
TES	Total eggs set
Wks	Weeks

Contents

History

All India Coordinated Research Project (AICRP) on Poultry Breeding has been the landmark development in the history of the poultry development in the country. AICRP started under commodity development programme of Indian Council of Agricultural Research (ICAR) during IV plan (1970), with the sole objectives of attaining self-sufficiency in egg and chicken meat production with high yielding germplasm in the country. The programme was carried out in ICAR institutes and also through research centers located in different State Agricultural Universities (SAUs). Initially, the council sanctioned two coordinated research projects entitled 'AICRP on Poultry for egg' and 'AICRP on Poultry for meat' to evolve suitable strains of egg and meat type chicken that combine well for production of commercial layers and broilers. Both the projects were subsequently merged into a single project entitled 'AICRP on Poultry Breeding' during fifth plan period with the same objectives. The coordinating unit was established at Division of Poultry Research, IVRI, Izatnagar, Bareilly, till October, 1979. Central Avian Research Institute (CARI) became the coordinating centre of this project w.e.f. 2nd November, 1979. The coordinating unit was headed by a full-time project coordinator and assisted by the Scientists of AICRP unit located at IVRI/CARI from different disciplines. The Project coordinator coordinated and monitored the work of the different centres and also organized other research programs related to poultry breeding.

Four centres were established during the IV plan period to carry out research on poultry for egg and four centres on poultry for meat. Four more centres, two each for egg and meat type chicken were added during the V plan, in addition to two sub-centres. While the main centres are primarily responsible for development of superior strains and testing of cross combinations, sub-centres are primarily responsible to test the efficiency of the superior strain crosses identified.

During the VI Plan period (1980-85) three additional units: Control Population Unit for egg, Control Population Unit for meat and Nucleus Stock Production Unit were sanctioned. Nucleus Stock Production Unit, however, could not be started during the VI Plan period due to administrative reasons.

Agartala, Sikkim, Bhubaneswar, Mathura, Madras and Akola centres of All India Coordinated Research Project on Poultry Breeding were transferred to the host Institutes with effect from 01-04-1985, 01-04-1985, 30-06-1986, 30-06-1986, 31-03-1990 and 31-03-1990, respectively. Anand and Ludhiana centres were upgraded to the status of full centres. The project envisaged undertaking Reciprocal Recurrent Selection (RRS) programme of layer stocks and specialized sire and dam line programme in broiler stocks besides the intra-population selection programme already in progress.

Subsequently, keeping in view the importance and magnitude of work involved, the coordinating unit of AICRP was upgraded to the status of Project Directorate on Poultry (PDP) during the VII Plan period to carry out research on poultry breeding, poultry nutrition and poultry housing and management. Research was also envisaged in the area of poultry nutrition, poultry housing and management, poultry health and market intelligence survey of poultry and poultry products. Identification of alternative feed resources, fair chemical usage & biological evaluation and development of least cost poultry rations were the focal areas in poultry nutrition research. In the discipline of poultry housing and management, biological efficiency of different management practices for economic poultry raising were evaluated. Surveillance and monitoring of poultry diseases and development of kits for quick diagnosis of diseases were set as main objectives of poultry health research. Subsequently, as per the council's decision, the research centres of AICRP on Poultry nutrition and poultry Housing and management at different SAU's were phased out from 01-04-1993.

The headquarters of the Project Directorate on Poultry was established at Andhra Pradesh Agricultural University, Rajendranagar, Hyderabad with effect from 1st March, 1988. Coordination and monitoring tasks were assigned to the Directorate (Coordination Cell) to start with. Subsequently, Nucleus Stock Production Unit as a centre of AICRP on Poultry Breeding was established at the Project Directorate for multiplication and supply of the parents and their commercial crosses released from the centres. From 1st April, 1990, the Project Directorate was entrusted with additional responsibilities of maintenance, evaluation, reproduction and supply of control populations of egg and meat to the coordinated centres. Maintenance of layer and broiler control populations previously maintained at HAU, Hisar and UAS, Bangalore, respectively was assigned to this Directorate w.e.f. 01.04.1990. The Directorate was also entrusted with the evaluation of commercial layers and broilers developed at different centres of the project vis-à-vis those available in the market from other hatchery sources and maintenance of the elite stocks of layers and broilers available in the country/to be imported from abroad in future and to undertake their genetic description and characterization with respect to biochemical, immunological and cytogenic traits and resistance to diseases. Supportive Research was also envisaged in the areas of poultry nutrition and poultry health. Besides coordinating and monitoring the research activities of AICRP, the Directorate has also concentrated on development and strengthening of infrastructure and laboratory facilities over the years.

During the year 2014-15, the Project Directorate on Poultry was upgraded to Directorate of Poultry Research. The mandate of the institute was broadened with the addition of basic research and capacity building components. During the same year, AICRP on Poultry Breeding was reoriented towards rural poultry with special focus on development of location-specific chicken varieties suitable for different agroclimatic regions of the country. Special emphasis was given to the promotion and propagation of rural poultry as tool for nutritional and livelihood security in rural and tribal areas of the country.

Mandate

1. To evolve high yielding strains/strain crosses with average annual egg production performance of 305 eggs hen housed and more than 54 g egg weight at 40 wks of age with less than 1% laying house mortality per month using conventional breeding and modern biotechnological tools to be achieved by the end of XI plan.
2. To evolve a commercial broiler with at least 1800 g body weight at 6 wks of age with feed efficiency less than 2.0 and less than 5% mortality up to 5 wks of age using conventional breeding and modern biotechnological tools to be achieved by the end of XI plan.
3. To develop location-specific germplasm for rural poultry production.
4. To test the rural varieties developed by various agencies i.e. ICAR and SAUs.

Objectives and Targets

Poultry for Egg

The research programmes carried out since its inception made significant progress in developing high yielding layer strains. The initial target of 220 eggs in 72 weeks was subsequently revised to 235, 250, 260 and 270 eggs and all were attained. The present targets include;

1. To evolve high yielding strains/strain crosses with average annual egg production performance of 305 eggs hen housed and more than 54 gm egg weight at 40 wks of age with less than 1% laying house mortality per month using conventional breeding and modern biotechnological tools.
2. To estimate genetic gains from selection in the principal and correlated traits.
3. To compare different breeding methods for improving the principal performance traits.
4. To maintain the elite layer strains and utilize them in development of location specific chicken varieties.

Poultry for Meat

Several high-yielding broiler strains have been developed since the beginning of the project. Initially, the objective was to evolve a commercial broiler with at least 1800 gm body weight at 6 wks of age with feed efficiency less than 2.0 and less than 5% mortality using conventional breeding and modern biotechnological tools. The set target was achieved and the following objectives were envisaged for poultry for meat component.

1. To evolve commercial broiler with at least 1500g body weight at 5-weeks of age.
2. To estimate genetic gains from selection in the principal and correlated traits.
3. To compare different breeding methods for improving the principal performance trait and reduction in size of broiler dam line through introduction of dwarf gene.
4. To maintain the elite broiler strains and utilize them in development of location specific chicken varieties.

Table i. AICRP Centres since beginning of the project

Sl. No	Name of the Centre	Period
1	Anand Agricultural University, Anand	06-07-1977 to 31-03-2023
2	Kerala Veterinary and Animal Science University (KVASU), Mannuthy	19-02-1977 to 31-03-2023
3	Karnataka Veterinary, Animal and Fishery Sciences University (KVAFSU), Bengaluru	14-01-1970 to 31-03-2023
4	ICAR-Central Avian Research Institute (ICAR-CARI), Izatnagar	01-04-1970 to 31-03-2023
5	Guru Angad Dev Veterinary and Animal Science University (GADASU), Ludhiana	26-02-1977 to 31-03-2023
6	Orissa University of Agriculture and Technology (OUAT), Bhubaneswar	21-01-1971 to 1990 and 01-09-1991 to 31-03-2023
7	ICAR Research Complex for NEH region, Tripura Centre (ICAR RC for NEH), Agartala	12.01.1977 to 31.03.1985 and 01-08-2001 to 31-03-2023
8	Nanaji Deshmukh Veterinary Science University (NDVSU), Jabalpur	11-06-1970 to 31-03-2023
9	Assam Agricultural University (AAU), Guwahati	23-03-2009 to 31-03-2023
10	Birsa Agricultural University (BAU), Ranchi	23-03-2009 to 31-03-2023
11	Maharana Pratap University of Agriculture & Technology (MPUAT), Udaipur	23-03-2009 to 31-03-2023
12	CSK Himachal Pradesh Krishi Viswavidyalaya (CASKHPKV), Palampur	23-03-2009 to 31-03-2023
13*	ICAR-Directorate of Poultry Research (ICAR-DPR), Hyderabad	Coordinating Unit
Centres phased out over the period		
14	Acharya NG Ranga Agricultural University (ANGRAU/APAU), Hyderabad	26.03.1971 to 31.03.2014
15	Chandra Sekhar Ajad University of Agricultural & Technology, (CSAUAT), Mathura	27.03.1971 to 30.06.1986
16	Tamil Nadu Agricultural Universit (TNAU), Madras	26.05.1971 to 31.03.1990
17	Dr. Punjabrao Deshmusk Krishi Vidyapeeth (PKV), Akola	28.02.1977 to 31.03.1990
18	Department of Animal Husbandry, Sikkim	03.04.1976 to 31.03.1985
19	Control population unit, HAU, Hisar and UAS, Bangalore	21.03.1983 to 31.03.1995
20	Nucleus stock production unit, CARI, Izatnagar	21.03.1983 to 31.03.1995

*Control Population Unit

Rural poultry

1. To develop location-specific germplasm for rural poultry production
2. To test the rural varieties developed by various agencies i.e. ICAR and SAUs.

Present Objectives

During the year 2014-15, AICRP on Poultry Breeding was reoriented towards rural poultry. The objectives of AICRP on Poultry Breeding are as follows:

1. To develop location-specific chicken varieties and their dissemination for village poultry.
2. Conservation, improvement, characterization and application of local native and elite layer and broiler germplasm.
3. To develop package of practices for village poultry and entrepreneurships in rural, tribal and backyard areas etc.

Gene pool and germplasm

Layer

Superior germplasm was collected from several indigenous and exotic sources at the beginning of the project. Eight indigenous strains namely midget, Victoria, TeM, Bhopal, IVRI, Delhi, Pantnagar and Lucknow were tested during 1971-72. In 1972-73, Lucknow, Bhopal, Delhi and Pantnagar strains of White Leghorn were dropped and the remaining four i.e. midget, Victoria, TeM and IVRI were further tested along with Bombay and Mychix strains along with two exotic strains of White Leghorn. These strains were then coded as IWA (midget), IWB (Victoria), IWE (TeM), IWD (IVRI), IWE (Bombay), IWF (Mychix) and two exotic strains as IWL and IWM. Subsequently, on the basis of performance at different centres IWB, IWL and IWE were discarded.

In March 1972, four exotic strains of white leghorn (WL), *viz.* IWG, IWH, IWI, and IWJ were imported from USA and Israel and were bred for genetic improvement of egg production traits under poultry for egg project. The total number of chicks imported in various strains ranged from 500-800 in females and 125-200 in male per strain. During the year 1972-73, it was decided to continue the improvement programme, with only four exotic strains *viz.* IWG, IWH, IWI, and IWJ. A random bred pedigreed control population was developed form IWH strain of WLH by randomly choosing 30-cockerels and 240 pullets as breeder parents. Initially, there were six centres of AICRP on egg, *viz.* CARI, Izatnagar (or IVRI), Mathura Veterinary College, APAU, Hyderabad, KAU, Mannuthy, GAU, Anand and JNKVV, Jabalpur. At CSAU, Mathura, IWA, IWB, IWE, IWD, IWE, IWF, IWL and IWM were tested initially and IWB and IWE were discarded based on their performance at different centres. IWL and IWM were sent to Jabalpur center subsequently.

At GAU, Anand, the RRS programme was initially implemented with IWD and IWK populations for five generations and thereafter, it was discontinued and the centre was assigned to carry out work on pure line improvement involving IWN and IWP populations, made available from KAU, Mannuthy.

At JNKVV, Jabalpur, the centre implemented the technical programme with IWM and IWN strains during the year 1989-90 and continued till 1991-92. IWM line was discontinued in the year 1992-93 and IWN line was discontinued in the year 1993-94 and thereafter, the centre was assigned to carry out research programme as a component unit of poultry for meat involving dwarf gene.

The basic germplasm made available to APAU, Hyderabad centre in 1971-72 constituted six indigenous and four exotic strains of WLH. After initial evaluation, two indigenous strains were discarded and breeding programme was continued with four indigenous and four exotic strains. After few cycles of selection, IWA, IWE and IWO were dropped and two exotic strains IWN and IWP were sent to the AICRP on Poultry, Mannuthy. The IWK strain was transferred to PDP, Hyderabad.

Subsequently, ANGRAU, Hyderabad worked with two indigenous strains IWD and IWF, KVASU, Mannuthy with IWN and IWP strains and CARI, Izatnagar, with two exotic strains of WLH, *viz.*IWH and IWI along with a random bred control population. CARI was also maintaining IWG and IWJ as resource populations.

At present, IWN and IWP strains are being maintained at KVASU, Mannuthy and AAU, Anand as elite layer populations. All other WLH strains (IWH, IWI, IWK, IWD, IWF and Control) are maintained at ICAR-DPR, Hyderabad as resource populations except IWH & IWI, which are under improvement program for higher 64 weeks egg production.

Broiler

Similarly, under *'Poultry for Meat'* component, the project operated with breeds suitable for broiler production. The three broiler strains (White Rock, New Hampshire and White Cornish) of ICAR sponsored scheme "Diallel crossing for broiler production" formed the base germplasm of AICRP on *'Poultry for Meat'.* The project was merged with AICRP during 1970. A white Rock strain, coded as 'IR-1' having single comb and yellow skin and a New Hampshire strain coded as 'IH-1' with single comb and yellow skin were used as a female lines. A White Cornish strain coded as 'IC-1' having pea comb and yellow skin was used as a male line.

During March-April 1972, four more broiler strains were imported and added to the gene pool of the project. They were two White Rock strains designated as IR-2 (a fast feathering recessive white strain recommended as a female line) and IR-3 (a dominant white plumage strain with better egg production and also was recommended as a female line). Two more strains of Cornish coded as 'IC-2' (with white plumage having pea comb and good body confirmation recommended to be used as a male line) and a Red Cornish line coded as 'IC-3' (having golden red plumage with single or pea comb also recommended to be used as a male line). The Bangalore centre of the project procured one more Cornish strain designated as 'IC-5' and a New Hampshire strain coded as 'IH-3' from a commercial hatchery within the country during 1971-72. Also, during the year 1972-73, a Cornish strain (IC-4) and a Rock strain (IR-4) were also imported from USA.

The Poultry for Meat component started operation at Bangalore, Madras, Izatnagar and Bhubaneswar in 1971. The Sikkim centre started in 1971 and it functioned with IR-2, IR-3, IC-2 and IC-3 strains received from Izatnagar. The Ludhiana centre became operational from 01-04-1977 and they utilized two synthetic populations developed at PAU. Those were coded as 'PB-1' and 'PB-2' which were undergoing selection for higher growth at eight weeks of age. Thus, the *'Poultry for Meat'* component, although started with five Cornish strains, four Rock strains, two New Hampshire strains and two synthetic populations, by 1985 two Cornish strains (IC-1 and IC-5), one Rock strain (IR-1) and both the New Hampshire strains (IH-1 and IH-3) were discontinued from breeding program. Thereafter, the project operated with three Cornish (IC-2, IC-3 and IC-4) three Rock (IR-2, IR-3 and IR-4) strains and two synthetic (PB-1 and PB-2) populations. A control population designated as PB-4 that originated from PB-1 was also utilized in the programme. Akola centre started in 1979, although, it was to function as a testing centre, it received some pure strains from Madras (IC-1 and IH-1) and from Bhubaneswar (IC-5) and from Bangalore (IR-4) in the year 1980-81.

During the year 1990, as per the recommendations of the Mid-term Appraisal Committee, Madras, Bhubaneswar and Akola centres were discontinued. During the year 1993-94 JNKVV, Jabalpur was made a component unit of AICRP for Meat to carry out the work involving dwarf gene carrying population. During the year 1991-92, OUAT, Bhubaneswar was re-included in the AICRP for Meat. From September 1991, it continued its research work on improvement of specialized sire (IC-3) and dam (IR-3) population till 1993-94. In the year 1994-95. the centre received synthetic male (PB-1) and female (PB-2) lines from CARI, Izatnagar.

Control populations

Although initially, attempts were made to develop control populations for layers and broilers at the respective centres, subsequent decision was made to have a centralized control population unit. This led to the establishment of layer and broiler control population units at HAU, Hisar and UAS, Bengaluru respectively in March, 1983 for propagation and maintenance of a layer control population. These populations were the source for samples of control population to the respective centres of the AICRP on Poultry for Egg and Poultry for Meat. However, the CARI, Izatnagar continued to have their own layer and broiler control populations and the PAU, Ludhiana continued with a meat control (PB-4) for some time. At present, the control populations are being maintained at ICAR-DPR, Hyderabad and are supplied to the centres as and when required.

Presently, PB-1 and PB-2 lines are being maintained at KVAFSU, Bengaluru and GADVASU, Ludhiana; CSML and CSFL at ICAR-CARI, Izatnagar and OUAT, Bhubaneswar. The broiler control population is being maintained at ICAR-DPR, Hyderabad.

Monitoring role of the Coordinating unit/ Directorate

Organization of Review Committee meeting/ Scientists meet/ workshops

1. Compilation of periodical reports received from individual centres for submission to ICAR and preparation of Annual Report of Project Directorate
2. Verification and scrutiny of proposals received from different centres in all aspects relating to budget, release of funds and in all other matters relating to the functioning of various centres and their onward transmission to ICAR
3. Preparation of EFC proposals
4. Preparation of DARE's report and research highlights
5. Compilation of data for answering the parliament questions
6. Visit to different centres of the Project for review of progress

Technical Programme

Genetic improvement of layer population

1. In the beginning of the project, a total of six indigenous and ten exotic strains of WLH were maintained at six AICRP centres for egg and selection programmes were carried out for higher egg production along with other related growth, production and reproduction traits. In due course of time, a total of six strains of WLH were discarded due to their poor performances.
2. The IWH, IWI, IWN, IWP, IWD and IWF strains have been identified as the most promising parents for producing commercial crosses by the Varietal Release Committee. IWG, IWJ and IWK will be maintained by the respective centres on a small population size as resource populations.
3. To improve the pure line performance, the selection criteria will be higher 64 week egg production based on Osborn Index. The entire flock of each population will be maintained till 64 –weeks of age and the following traits will be measured.
   i. Age at first egg.
   ii. Body weight at 16, 40 and 64-weeks of age.
   iii. Egg weight at 28, 40 and 64-weeks of age. For those populations having low egg weight, the first ten eggs also need to be measured.
   iv. Egg production at 40 and 64-weeks of age and computation of egg production on hen housed and hen day basis.
   v. A random sample of 100 eggs will be utilized at 40-weeks of age to measure albumen height and index, yolk height and index and shell thickness and Haugh unit score. The percentage of blood and meat spots will also be recorded.
   vi. Percent fertility and percent hatchability on total and fertile eggs set will be measured. The minimum expectation will be more than 90% fertility and 80% hatchability on fertile eggs set.
   vii. Mortality during the following periods.
      a. 0-8 weeks
      b. 9-16 weeks
      c. 17-40 weeks
      d. 41-64 weeks
      e. 17-64 weeks

   The minimum expectation will be less than 6% mortality during 0-8 weeks, less than 5% mortality during 9-16 weeks and less than 1% mortality per month during the period of 17-64 weeks in the layer house.
4. Only 300 females and 50 males will be selected from each population to reproduce next generation (only by artificial insemination). It is expected that in five hatches of 10 days interval, a total of 2500-3000 female chicksv will be hatched for each population.
5. A total of 2000-2500 pullets for each population will be housed at 16 weeks of age in individual laying cages for generating the data on traits mentioned above. The desired number of males needs to be housed for each population.
6. Only 600 males will be retained at 16 weeks of age at the rate of two males per dam family. They may be housed either in cages or on deep litter in floor pens depending on the available facilities.
7. The hen housed egg production up to 64 weeks of age will be the criterion of selection.
8. Selection in both the sexes will be practiced for 64 weeks, hen housed egg production and 28 weeks egg weight. Selection for egg production will be carried out on the basis of an index that takes into account individual production and its sire and dam family averages (Osborne Index). The selection for

28 week egg weight, will be utilized as independent culling level selection to be superimposed over the selection for 64 weeks egg number. For giving due weightage to viability, in selection programme only hen housed family average need to be used in computation of Osborne index values.

9. Based on the index values, only 450 pullets will be selected and subjected to independent culling levels for 28 week egg weight. Finally, only 300 pullets with higher egg production having better egg weight and shell thickness will be selected.
10. The chicks will be sexed at hatching, in all layer populations and all the females and only 900 males at the rate of 18 males per sire family will be saved. All male chicks will be dubbed.
11. All centres will keep a sample of layer control females hatched from the hatching eggs received from PD on Poultry (at least 200 females will have to be housed at 16 weeks of age). They will also be evaluated along with the selected populations.

Programme for layer control population

The technical programme for control population includes pedigreed random breeding without any seletion to measure the genetic progress. Each population will be reproduced using 50 sires, each sire mating to 4 dams and 4 progeny per dam are to be studied for various growth, production and reproduction traits. In order to obtain 4 progenies for each dam at the time of housing, suitable number of chicks are to be hatched accordingly.

The following traits are to be measured in case of layer control population:

i. Body weight at 16, 40 and 64 weeks of age.
ii. Age at first egg
iii. Egg weight at 28 and 40 weeks of age
iv. Egg production to 40 weeks of age and 64 weeks of age
v. Percent fertility and hatchability on total and fertile eggs set.
vi. Egg quality traits like albumen index, yolk index, shell thickness and percentage blood and meat spot on a sample of 100 eggs at 40 weeks of age.
vii. Mortality during the following period 0-8 weeks, 9-16 weeks, 17-40 weeks, 40-64 weeks and 17-64 weeks.
viii. About 700 eggs need to be supplied to each centre from the Directorate for evaluation of environmental trends.

Genetic improvement of meat population

Development of dam line population

1. The Centres involved in development of dam line population will produce 7,000 chicks in each generation.
2. At least 6000 chicks will contribute to data at 5 weeks for making necessary selection.
3. Between 5th and 6th week, out of the 3000 females, a total of 1400 females will be selected by mass selection based on 5 weeks body weight.
4. Among the 3000 males, 300 best males will be on the basis of body weight at 5 weeks.
5. At the age of 12 weeks, physical selection will be taken up and 1200 females without any physical defects will be retained and 250 males will also be retained after screening them for satisfactory physical appearance.
6. At 18 weeks of age, all the surviving females (out of a total of 1200 selected at 12 weeks) will be housed in individual cages. The minimum numbers of females at this stage should be 900.
7. Simultaneously, 200 best males out of the 250 males physically selected at 12 weeks of age will also be housed in cages or on deep litter.
8. The females will be evaluated for dam line traits till the time the youngest hatch attains 40 weeks of age and sire family selection will be practiced.

9. Out of the surviving females, a total of 560 females will be selected and will be mated to 70 best males selected from the available 200 males housed at 18 weeks of age to obtain replacement progeny. (The artificial insemination is mandatory to reproduce the next generation so as to ensure high percentage fertility and good number of chicks.)
10. It is estimated that in 4 to 5 hatches of 7 to 10 days interval, the required number of chicks can be reproduced from the 560 selected female breeders mated to 70 selected male breeders.
11. The criterion of selection for the females will be the sire means for settable egg production. Similarly, the males from the sire families from which females have been chosen will be selected as male parents.
12. The shape index of the eggs needs to be measured at 32 weeks of age by measuring the length and width of egg. It is desirable to measure the shape index for five consecutive days. The acceptable shape index is suggested as 1.30 to 1.50.

Restriction programme: Since the birds are selected at five weeks of age, a graph has to be generated assuming a target weight of 2150 to 2200g at 20 weeks of age. Assuming linearity, a graph has to be developed starting from the mean weight of the selected birds at 5 weeks of age and the expected body weight at bi-weekly interval needs to be measured as applicable to populations at each centre. The trend of the body weight at different ages during the restriction program needs to be plotted along with the expected line. Based on the graph, feed needs to be increased or maintained accordingly. The allowance arrived, as per the graph, at different ages can be increased by 10 percent in case of males for achieving similar trend of body weight during the restriction period.

Development of sire line population

1. The available synthetic coloured broiler population will be utilized in the programme.
2. The centres involved in the sire line population development need to produce and evaluate 8000 chicks in each cycle.
3. It is assumed that above 7000 chicks will contribute to body weight measurement at 5 weeks of age.
4. 1000 females and 250 males will be selected based on mass selection for higher 5 weeks body weight
5. At 10 weeks of age, the number of females need to be brought down to 800 and the number of males to 200 after necessary rejection on the basis of physical defects and sexing errors.
6. At 24 weeks of age, a total of 600 females and 150 males are to be finally selected and evaluated till the time the youngest hatch reaches 34 weeks of age.
7. Among the available females, the ten percent late maturing females are to be rejected.
8. This way about 500 females and 60 best males will be selected as breeders for reproducing the next cycle.
9. The next generation will be regenerated in 4-5 hatches of 10 days interval, it will be possible to generate the required number of chicks for the next generation.
10. The criterion of selection will be the five weeks body weight for both males and females.

Restriction programme: Starting with the 5 weeks mean body weight of the selected females and assuming the body weight of 2400 g at 20 weeks, the necessary graph needs to be drawn assuming a linear trend. In case of males, a body weight of 2800 g at 20 weeks of age could be allowed.

Feed formulation: To keep the nutrient content uniform at all the centres, the following recommendations have been provided:

Table ii. Nutrient composition of poultry diets

Nutrient	Chicks (0-5 wks)	Growers (6-18 wks)	Prebreeders (19-23 wks)	Breeders (24-54 wks)
Energy (kcal/kg)	2800-2850	2750-2800	2750-2800	2800
Protein (%)	20	16	16	17
Lysine (%)	1.00	0.80	0.80	0.75
Methionine (%)	0.52	0.41	0.41	0.35
Ca (%)	1.0	1.0	2.00	- 3.5
Phosphorus (%)	0.45-0.50	0.45	0.45	0.45
Choline Chloride 50% (%)	0.1	0.1	0.1	0.1
Sodium Chloride (%)	0.4	0.4	0.4	0.4

Programme for dwarf dam line

1. The centre dealing with dwarf gene carrying population will maintain the single source population as pure line dwarf population. The two sub-lines (DBE and DBG) available are to be put together and the best males and the females based on the evaluation of their egg production and early egg size needs to be selected.
2. The centre will produce and evaluate 5000 pure line dwarf chicks.
3. A total of 1500 females and 300 males will be selected at six weeks of age.
4. a) Colour population carrying sex linked recessive dwarf gene will be maintained for evaluation of dam line traits.

   b) At the age of 12 weeks, the numbers will be reduced to 1200 females and 250 males through physical selection.
5. At the age of 18 weeks, all the surviving females will be housed in cages for evaluating their egg production.
6. At this age, a total of 150 males also will be housed. Altogether, a total of 1000 males and females will be housed for data collection.
7. The females will be evaluated for their egg production, early egg size and age at maturity.
8. The best 100 males will be each mated to 9 normal bodied broiler dams representing three different dam line populations.
9. The centre will obtain hatching eggs of the dam line before the hatching programme of the dwarf is taken up. The required number of hatching eggs will be obtained so as to ensure the availability of 300 to 350 normal bodied dam line females from each of the population.
10. Thus, each of the 100 best dwarf males will be mated to the normal bodied females, from three dam lines, obtained from the other AICRP centres where the dam line programme is in operation.
11. Post measurement of six weeks body weight, all the males of the broiler dam line will be sold away and about 500 females from each of the three dam lines will be retained. This will ensure the availability of 300 to 350 normal bodied dam line females for mating with the 100 best dwarf males and this mating produce around 600 crossbred dwarf dams from females of the each of the dam line population.
12. In this way, each sire of the dwarf population would have produced 18 to 20 dwarf dams, and therefore, the egg production and other dam line traits of these 1800 dwarf dams (18x100 = 1800) representing the three normal bodied dam lines will be evaluated.
13. These dwarf dam females will be evaluated for early egg weight, the settable egg number, feed consumed for 12 settable eggs, percent fertility and percent hatchability (through test inseminations) and will also be evaluated for age at maturity.
14. The 100 sires that have produced the crossbred dwarf dams will be ranked as per the mean performance of each sire averaged over all the hen housed dwarf dams.
15. Based on the sire means, 50 sires will be selected and they will be mated to 300 dwarf pure line females selected on their own performance for age at maturity, settable egg number, early egg weight etc.
16. The pure line dwarf population will thus be reproduced from these 50 selected sires and 300 selected dams and the required number of chicks will be reproduced in 3-4 hatches of 10-12 days interval.
17. The crossbred dwarf dams while under evaluation could be mated to a sample of sire line males (to be obtained from the nearest AICRP centre working with sire line) to produce commercial normal bodied broiler chicks.
18. The centre will evaluate 800 pullets from the dwarf coloured female line for various production traits up to 52 weeks of age.
19. The centre will produce 5000 chicks of pure line colour dwarf population.
20. At 8 weeks of age, only 1500 females and 300 males will be retained.
21. At 12 weeks of age, population size will be further reduced to 1200 females and 200 males on physical basis of selection.
22. At 18 weeks of age, only 800 females will be housed for evaluating dam line traits and 150 males will be kept for reproducing next generation.

Programme for broiler control population

The technical programme currently under progress for control populations for meat will be continued. Each population will be reproduced using 50 sires, each sire mating to 4 dams and 4 progeny per dam are to be studied for various growth, production and reproduction traits. In order to obtain 4 progenies from each dam at the time of housing, the suitable number of chicks are to be hatched.

In case of broiler control population, the following traits are to be measured:

1. Body weight at day old, 5, 20 and 40 weeks of age
2. Feed consumption to 5 weeks of age
3. Age at first egg
4. Egg production to 40 weeks of age
5. Egg weight at 40 weeks of age
6. Percent fertility and hatchability on total and fertile eggs set
7. Mortality during the following periods: 0-5 weeks, 6-20 weeks, 21-40 weeks
8. Restricted feeding programme is to be practiced from 6^{th} to 20^{th} week.

About 300 to 400 hatching eggs of control line are to be supplied to each of the broiler centres of the Project Directorate during their hatching season, for evaluation of environmental trend

Technical programme (2022-2023)

- Pedigreed hatching and evaluation of the local native chicken.
- Procurement and evaluation of improved chicken germplasm in the local climatic condition and for development of cross.
- Production and evaluation of crosses of local native birds with improved germplasm.
- Development and evaluation of terminal crosses (location specific germplasm)

Native chicken

Genetic improvement of native chicken for body weight as well as egg production may be practiced for bringing faster genetic gain in the terminal crosses.

Selection criteria: Mass Selection for higher 16-week body weight and independent culling level for 40-week egg production

- Regeneration in pedigreed mating with 50 sires and 250 dams
- Production of about 1500 chicks
- Selection for body weight at 16 weeks: Mass Selection
- About 400-500 females and 200-250 males will be housed
- Selection for egg production at 40 weeks: Independent Culling Level
- About 250 dams and 50 sires will be selected as parents for next generation.

If there is demand for new type of variety (cross) the centre should conduct survey and establish the need for second variety before starting the work. The centres are strictly instructed to start the work only after the approval of the competent authority.

Traits to be recorded

- Body Weight at 20 and 40 wks
- ASM
- Egg weight at 28 and 40 wks
- Egg production to 72 wks
- Mortality - 0-6, 7-20, 21-40 and 41-72 wks
- Field Evaluation of about 250 birds under backyard/ free range

Development of crosses

The centre needs to conduct a survey in the region for the consumer preference and acceptability for the type of variety. Based on the survey, a decision is to be taken about the type of chicken variety either dual or egg type, to be developed by the centre

Flocks to be selected for Rural Poultry

- Local native chicken (with better phenotypic performance) in the respective agro-climatic zones

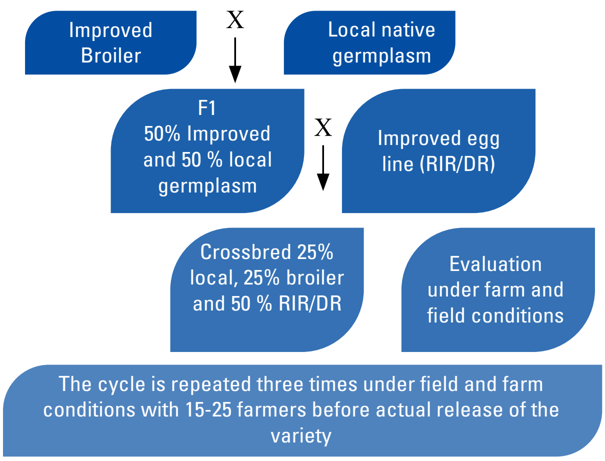
Improved egg type or meat type chicken developed by ICAR/ SAUs to be procured.

Conservation of elite germplasm

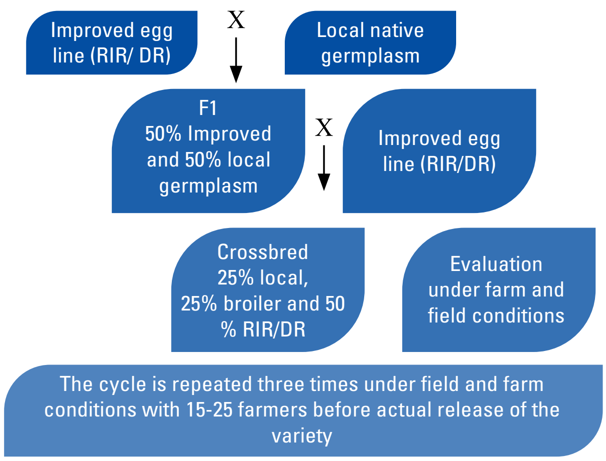
A. Technical programme for layers

1. Layer centres will work on maintenance of elite layer populations.
2. Collection, characterization and conservation of local native germ plasm.
3. Production and evaluation of crosses under farm and field conditions.
4. Development of location specific varieties.
5. Impact assessment
6. The strains that are being maintained at present will be continued. IWH, IWI, IWD, IWF and IWK will be maintained at ICAR-DPR, Hyderabad. IWN and IWP, strains will be maintained since they have been identified as most promising, lines.
7. To maintain the pure line performance, the selection programme currently under progress in the AICRP will be continued with lesser intensity of selection. The entire flock of each population will be maintained till 64 weeks of age. The following traits will be measured:
   - Age at first egg
   - Body weight at 16, 40 and 64 weeks of age.
   - Egg weight at 28, 40 and 64 weeks of age.
   - For those populations having low egg weight, the first ten eggs also need to be measured.
   - Egg production to 40 and 64 weeks of age and computation of egg production on hen housed and hen day basis.
   - A random sample of 100 eggs will be utilized at 40 weeks of age to measure albumen height and index, yolk height and index and shell thickness and Haugh unit score. The percentage of blood and meat spots will also be recorded.
   - Percent fertility and percent hatchability on total and fertile eggs set will be measured. The minimum expectation will be more than 90% fertility and 80% hatchability on fertile eggs set.
   - Mortality during the following periods: 0-8, 9-16, 17-40, 41-64 and 17-64 weeks of age.
   - The minimum expectation will be less than 6% mortality during 0-8 weeks. Less than 5% mortality during 9-16 weeks. Less than 1% mortality per month during the period 17-64 weeks in the layer house.

Technical program: Dual Type chicken



Technical program for Egg type chicken



- Among the selected breeders, three eggs from each female will be broken for measuring the shell thickness. Breeders with very thin shell eggs will be replaced by breeders with better egg shell thickness before the mating are arranged.

8. All centres will maintain all the surviving birds of first hatch to record egg production till 72 weeks of age.
9. Only 350 females and 50 males will be selected from each population to reproduce next generation (only by artificial insemination). It is expected that in four hatches of 10 days interval, a total of 1400 female chicks and 500 male chicks will be retained for each population.
10. A total of at least 600 pullets for each population will be housed at 16 weeks of age in individual laying cages for generating the data. The desired number of males will have to be housed for each population.
11. Only 300 males will be retained at 16 weeks of age at the rate of six males per sire family. They may be housed either in cages or on deep litter in floor pens depending on the available facilities (all care should be taken to prevent mortality in the males, saved at 16 weeks, as it will affect the selection differential from the male side and also the average selection differential).
12. The hen housed egg production up to 64 weeks of age will be the criterion of selection.
13. The selection will be practiced in both the sexes for 64 weeks hen housed egg production and 28 weeks egg weight. Selection for egg production will be carried out on the basis of an index that takes into account individual production and its sire and dam family averages (Osborne, 1957 a and b). The selection for egg weight, obtained at 28 weeks, will be utilized as independent culling level selection to be superimposed over the selection for 64 weeks egg number. For giving due weightage to viability, in selection programme only hen housed family average need to be used in computation of Osborne index values.
14. Based on the index values, only 450 pullets will be selected on the basis of egg production. Out of these 450 pullets, based on the low early egg weight and shell thickness, 100 pullets will be rejected. Thus, finally only 350 pullets and 50 males will be selected which are good for egg production having better egg weight and with good shell thickness.
15. The chicks will be sexed at hatching, in all layer populations and 1400 females and 500 males at the rate of 10 males per sire family will be saved. All male chicks will be dubbed.
16. All centres will keep a sample of layer control females hatched from the hatching eggs received from ICAR-Directorate of Poultry Research (at least 200 females will have to be housed at 16 weeks of age). They will also be evaluated along with the selected populations.
17. Uniform reporting of the data by all the centres.
18. Maximum publicity through media for popularizing high yielding strains/varieties developed by AICRP on Poultry Breeding.
19. Each centre will record rate of lay and persistency of peak production.
20. The layer control will be supplied by ICAR-DPR to all the centres.

Programme for layer control population

The technical programme currently under progress for control populations for egg will be continued. Each population will be reproduced using 50 sires, each sire mating to 4 dams and 4 progeny per dam are to be studied for various growth, production and reproduction traits. In order to obtain 4 progenies for each dam at the time of housing, the suitable numbers of chicks are to be hatched. The following traits are to be measured in case of layer control population.

1. Body weight at 16, 40 and 64 weeks of age
2. Age at first egg
3. Egg weight at 28 and 40 weeks of age
4. Egg production to 40 weeks of age and 64 weeks of age
5. Per cent fertility and hatchability on total and fertile eggs set

6. Egg quality traits like albumin index, yolk index, shell thickness and percentage blood and meat spot on a sample of 100 eggs at 40 weeks of age.
7. Mortality during the following period 0-8, 9-16, 17 to 40, 40-64 and 17-64 weeks.
8. About 500 eggs are to be supplied to each egg centre from the Project Directorate for evaluation of environmental trends.

B. Technical programme for broilers

Development of sire and dam line population

1. Broiler centres will work on maintenance of elite broiler populations.
2. Collection, characterization and conservation of local native germ plasm.
3. Production and evaluation of crosses under farm and field conditions.
4. Development of location specific varieties and impact assessment
5. The centres will continue to develop the existing female line available with them.
6. Centres involved in development of dam line population will produce 3,500 chicks in each generation.
7. It is expected that at least 3000 chicks will contribute to data at 5 weeks for making necessary selection.
8. Between 5th and 6th week, a total of 1200 females will be selected based on five weeks body weight.
9. A total of 250 best males will also be selected on body weight at 5 weeks.
10. At the age of 12 weeks a physical selection will be taken up and 1000 females without any physical defects will be retained and 200 males will also be retained after screening them for satisfactory physical appearance.
11. About 500 females will be housed in individual cages.
12. Simultaneously, 150 best males out of the 200 males will also be housed in cages or on deep litter.
13. The females will be evaluated for dam line traits till the time the youngest hatch attains 40 weeks of age and sire family selection will be practiced.
14. Out of the surviving females, a total of 350 females will be selected and will be mated to 70 best males selected from the available 200 males housed at 18 weeks of age to obtain replacement progeny (The artificial insemination is mandatory to reproduce the next generation so as to ensure high percentage fertility and good number of chicks).
15. It is estimated that in 4 to 5 hatches of 7 to 10 days interval, the required number of chicks can be reproduced from the 350 selected female breeders mated to 70 selected male breeders.
16. The criterion of selection, for the females, will be the sire means for settable egg production. Similarly, the males from the sire families from which females have been chosen will be selected as male parents.
17. The shape index of the eggs needs to be measured at 32 weeks of age by measuring the length and width of egg. It is desirable to measure the shape index for five consecutive days. The acceptable shape index is suggested as 1.30 to 1.50.

Restriction programme: Since the birds are selected at 5 weeks of age, a graph has to be generated assuming a target body weight of 2150 to 2200g at 20 weeks of age in dam line and 2400g at 20 weeks in sire line. Assuming linearity, a graph has to be developed starting from the mean weight of the selected birds at 5 weeks of age and the expected body weight at bi-weekly interval need to be identified as applicable to populations at each centre. The trend of the body weight at different ages during the restriction program needs to be plotted along with the expected line. The feed needs to be increased or retained the same according to the adjustment needed for matching with the proposed graph. The allowance arrived, as per the graph, at different ages can be increased by 10 percent in case of males for achieving similar trend of body weight during the restriction period.

ICAR-DPR, Hyderabad

1. This centre will maintain the pure lines that are being withdrawn from different centres as nucleus stock.
2. Regeneration and supply of control population to different centres for evaluation of selected lines.

Programme for broiler control population

The technical programme currently under progress for control populations for meat will be continued. Each population will be re-produced using 50 sires, each sire mating to 4 dams and 4 progeny per dam are to be studied for various growth, production and reproduction traits. In order to obtain 4 progenies for each dam at the time of housing, the suitable number of chicks is to be hatched.

In case of broiler control population, the following traits are to be measured:

1. Body weight at day old, 5, 20 and 40 weeks of age
2. Feed consumption to 5 weeks of age
3. Age at first egg
4. Egg production to 40 weeks of age
5. Egg weight at 40 weeks of age
6. Per cent fertility and hatchability on total and fertile eggs set
7. Mortality during the following periods 0-5 weeks, 6-20 weeks, 21-40 weeks
8. Restricted feeding programme is to be practiced from 6 to 20th week.
9. About 300 to 400 hatching eggs of Control line are to be supplied to each of the broiler centres of the ICAR-Directorate of Poultry Research during their hatching season, for evaluation of environmental trends.

Significant Achievements

The major objective of the AICRP on poultry breeding was to develop high yielding strains for improving the productivity of the layer and broiler populations in the country. The research on commercial poultry varieties was initiated during IV five plan during 1970 onwards. Rural component was added in 2000-01 and subsequently the project was completely oriented towards rural poultry from 2014-15 with major emphasis on development of location specific chicken varieties and conservation of indigenous chicken breeds. The research work was focused towards varietal development along with nutrition, housing, management and health care practices for the two plan periods. A total of seven chicken varieties for commercial intensive farming and five location specific chicken varieties for rural poultry farming have been developed and released for commercial exploitation. The varieties developed at AICRP on Poultry Breeding centres are detailed below.

Commercial varieties

Layer varieties

- Athulya (KAU, Mannuthy),
- ILR-90 (ANGRAU/SVVU, Hyderabad)
- ILI-80 (CARI, Izatnagar),
- Anand Commercial layer (AAU, Anand)

Broiler varieties

- B-77 and IBL-91 (CARI, Izatnagar),
- IBL-80 (PAU, Ludhiana) and
- IBB-83 (UAS, Bangalore).

Location specific rural poultry varieties

- Pratapdhan
- Narmadanidhi
- Kamrupa
- Jharsim
- Himsamridhi
- Toqbari

Layer varieties

Athulya

All India Co-ordinated Research Project on Poultry breeding, Mannuthy, Kerala has developed a commercial layer named **ILM-90 (ATHULYA)** by crossing White Leghorn P Strain with White Leghorn N strain which yields more than 300 eggs up to 72weeks of age. This hybrid layer is suited for commercial egg production in both deep litter and cage rearing. The birds are characterized by white plumage, single comb and yellow shank colour.

The standard management practices of commercial layer management including nursery, grower and layer management principles are followed for rearing the birds.

Athulya (ILM 90) layers

Table iii. Performance of Athulya layer under farmers field conditions

Trait	Performance
Body weight, g	1174
16 wks	
40 wks	1589
64 wks	1788
Egg production up to 72 weeks, Nos	303
Mean egg weight, g	57
Egg shell Colour	White
Feed consumption/day, g	120
Feed/dozen eggs, kg	1.8
Livability, %	98

Table iv. Performance of Anand commercial layer

Trait	Performance
Age at first egg, days	142
Egg production, 72 weeks, Nos.	300
Egg weight, 40 weeks, g	52
Egg weight, 40 weeks, g	54

Table v. Performance of ILR-90 Jubilee birds

Particulars	ILR-90 Jubilee
Age at first egg, days	156
Body weight, g	
16 wks	1063
20 wks	1342
40 wks	1360
Egg weight, g	
28 wks	49.8
40 wks	54.1
Egg production, Nos.	
40 wks	114
64 wks	256
72 wks	296

Anand Commercial layer

Anand Commercial Layer which is high yielding White Leghorn poultry strain-cross (IWN X IWP) was released at state level in tenth meeting of combined joint Agricultural Research Council (AGRESCO) of State Agricultural Universities of Gujarat held during 9th to 11th April, 2014. The performance of Atulya layers is presented in Table iii.

Anand commercial layer hen

ILR-90 (JUBILEE)

ILR 90 (JUBILEE) is a commercial cross of Pure lines IWD and IWF developed at AICRP on Poultry Breeding, Rajendrangar, Hyderabad. The birds produce 288 eggs on hen housed and 290 eggs on hen day basis (Table iv) with mortality of 1% from 0-20 weeks and recording 92.5% of laying house livability during production period. Average feed consumption was 96.20 gm/day/bird with feed efficiency of 1.5 kg of feed to produce a dozen eggs.

ILR jubilee 90 commercial layer

Broiler varieties

IBL-80

IBL-80 is a coloured broiler commercial variety produced by crossing PB-1 and PB-2. The birds attain a body weight of 1.6 -1.8 kg at 6 weeks of age, the market age of the broiler. The FCR up to 6 weeks of age ranges from 1.9-2.0. The liveability of the birds is 95-97%. The dressing percentage is about 70 %. The birds have optimum meat quality and are preferred by the farmers.

IBL-80

Raja-II

The colour broiler variety, RAJA-II, produced from crossing PB-1 and PB-2 is popular in Karnataka. The birds are preferred for better meat quality as the birds have tough meat texture compared to the white broiler. The body weight at six weeks of age ranges from 1.5-1.7 kg, often farmers keep birds up to 7 weeks of age which weigh about 2.0 kg. The FCR up to 6 weeks of age is 2.0-2.2. The survivability is about 96%. The dressing percentage is about 70%. The birds have better acceptability among the rural and peri urban farmers in Karnataka.

Raja-II

Location specific rural poultry varieties

Pratapdhan

Pratapdhan, a dual purpose variety developed at AICRP on Poultry Breeding, MPUAT, Udaipur, Rajasthan. The bird is a 3-way cross evolved from Native X PB-2 X RIR chicken. Birds have multi coloured plumage and well accepted in dry arid region. Birds have longer shank length which helps in self-protection from predators in backyard areas and has capacity to survive on low plane of nutrition and harsh climatic conditions. *Pratapdhan* has fast growth rate with average adult body weight of 2.4 kg in males and 1.9 kg in females (Table vi). The age at sexual maturity was 170 days. Pratapdhan produces 165 eggs annually under field conditions. A total of 4.8 lakh Pratapdhan germplasm has been distributed to 9340 farmers in tribal and rural areas of Rajasthan. Farmer can earn a total of Rs.8600/- net profit from a unit of 20 birds.

Table vi. Performance of Pratapdhan birds

Traits			Performance
Body weight, g			
	8 wks		678
	20 wks	Male	2400
		Female	1900
	40 wks	Male	2700
		Female	2200
Age at sexual maturity, d			170
Egg weight 40 wks, g			54
Egg production 72 wks, nos			165

Pratapdhan birds

Narmadanidhi

Narmadanidhi, a multi coloured dual purpose bird developed at AICRP on Poultry Breeding, NDVSU, Jabalpur. Narmadanidhi is three way cross with 25% Kadaknath and 75% Jabalpur colour inheritance. The plumage colour pattern varies from black, brown, barred, grey and mixed colours. These birds perform better and adopted well under village farming condition, having very less mortality, less predation due to its medium size weight, strong legs and long shank along with flight characteristics. Male birds weigh about 1 kg at 10-12 weeks of age. The adult body weight ranged from 1.6 to 2.2 kg in males and 1.3 to 1.7 kg in females (Table vii). The annual egg production is about 165-180 eggs under backyard system. A total of 2.85 lakh Narmadanidhi germplasm has been distributed to 1137 farmers in Madhya Pradesh and adjoining states. Farmer earns an amount of Rs. 13000/- profit from a unit of 20 birds of Narmadanidhi.

Table vii. Performance of Narmadanidhi under free range

Trait		Performance
Body weights, g		
8 wks		670
20 wks	Male	1632
	Female	1406
40 wks	Male	2310
	Female	1730
Age at sexual maturity, d		
Egg weight 40 wks, g		48.0
Egg production 72 wks, Nos.		173

Kamrupa

Kamrupa, a multi-coloured bird for rural poultry production developed under AICRP on Poultry Breeding at Assam Agriculture University, Khanapara, Guwahati, Assam. Kamrupa is a 3 way cross involving Native X PB-2 X DR with 25% native inheritance. The birds are medium in weight and have longer shanks enabling them to protect from the common predators. The Kamrupa bird has similarity of the typical appearance to the local birds in respect of feather colour and plumage pattern. Therefore, it is well accepted by the rural farmers. The body weight of adult birds is 1.5 kg in male and 1.2 kg in female, respectively under backyards. The annual egg production is 120-140 eggs with an egg weight of 52g (Table viii). The variety performed well in rural, hilly and harsh ecosystem of NEH region. A total of 1.32 lakh Kamrupa germplasm has been distributed to 17620 farmers in Assam and NEH region. A farmer can earn an average profit of Rs. 6444/- from a unit of 20 birds with Rs 644 from a pair of birds.

Table viii. Performance of Kamrupa birds under field conditions

Trait		Performance
Body weights, g		
8 wks		575
20 wks	Male	1500
	Female	1150
40 wks	Male	2000
	Female	1450
72 wks	Female	1580
Age at sexual maturity, d		
Egg weight 40 wks, g		52.0
Egg production 72 wks, nos		130


Kamrupa birds in Assam

Jharsim

Jharsim, a multi-coloured dual purpose bird suitable for rural poultry production was developed at AICRP on Poultry Breeding, BAU, Ranchi, Jharkhand. Jharsim is a 3 way cross of Dahlem RedXPB-2 X Native chicken with 25% native inheritance. The adult body weight of males and females ranged from 1.5 to 2 kg and 1.4 to 1.6 kg (Table ix). The annual egg production was 130-135 eggs in backyard free range system. In Jharkhand, a small unit of 10-20 birds is reared for egg purpose under free range system. The birds are also suitable for meat purpose in large number in semi intensive system. A total of 1.26 lakh Jharsim germplasm has been distributed to 3029 farmers in tribal and rural areas of Jharkhand.

Table ix. Performance of Jharsim birds

Trait	Performance
Body weights, g	
8 wks	450
20 wks Male	1470
Female	1310
40 wks Male	
Female	
72 wks Female	
Age at sexual maturity, d	170
Egg weight 40 wks, g	53
Egg production 72 wks, Nos	133


Jharsim birds in farmers households

Himsamridhi

Himsamridhi, a dual purpose location specific rural chicken variety suitable for rural/backyard poultry farming in hilly regions was developed under under AICRP on Poultry Breeding at CSKHPKVV, Palampur, Himachal Pradesh. The cross is 3 way cross (DRXNativeXDR) with 75% Dahlem Red and 25% native inheritance. The birds have brown plumage pattern and adapted to the hilly ecosystem of the Himachal Pradesh.The performance of Himsamridhi birds is presented in Table x. The adult body weight was about 1.7 kg in males and 1.2 kg in females under field conditions. The annual egg production is about 150 eggs with an egg weight of 55g under backyard system. A total of 1.00 lakh Himsamridhi germplasm has been distributed to 1187 farmers in tribal and hilly areas of Himachal Pradesh. Farmer can earn Rs. 12000/- net profit from a unit of 20 birds in Himachal region (High profit is due to high price for eggs. Rs 10/egg).

Table x. Performance of Himsamridhi Birds under free range conditions

Trait	Performance
Body weights, g	
8 wks	400
20 wks Male	1660
Female	1240
40 wks Male	2140
Female	1560
72 wks Female	
Age at sexual maturity, d	207
Egg weight 40 wks, g	53
Egg production 72 wks, Nos	140

Himsamridhi birds in farmers households in Himachal Pradesh

Tokbari

'Tokbari' is a location specific multicoloured bird developed at AICRP on Poultry Breeding, ICAR RC for NEH, Tripura Centre, Agartala. The genetic composition of dual purpose chicken variety is Coloured Broiler (25%), Tripura Black (25%) and Dahlem Red (50%). Tokbari has attractive multi-coloured feather pattern with moderate body weight, good escaping ability and scavenging habits and suitable for rural backyard poultry farming in NEH Region. The annual egg production was 150-170 and 130-150 eggs at institute farm and at the farmer's fields respectively. The egg weight at 40 wk of age at Institute farm and farmers fields was 50-55 and 45-50 g respectively. The Tokbari backyard birds had 8% lower age at maturity than native birds. The egg weight is 26% higher and annual egg production is 133% higher than the native birds at farmer's fields. It is comparatively heavier than local desi birds with faster growth potential and possesses good immunity and can thrive well on low plane of nutrition. The farmers are satisfied by the growth and egg production potential of theToqbari birds. The newly developed Tokbari poultry variety is well adapted to local agro climatic condition and is readily accepted by farmers as bird of choice for backyard poultry farming in rural areas.

Tokbari birds

Table xi. Germplasm distribution (Nos) by different centres of AICRP on Poultry breeding

Centre	upto 2012	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	Total
KVASU, Mannuthy	186838	28858	22477	14866	35387	136743	216397	133829	107142	122876	30238	1035651
AAU, Anand	29676	2055	600	18066	44337	39474	49036	46983	62530	55528	70311	418596
SVVU, Hyderabad	75622	5000	5100	8000	0	0	0	0		0	0	93722
CARI (layer)	602874	5559	0	0	0	0	0	0		0	0	608433
KVAFSU, Bengaluru	1988312	126995	139277	145014	117998	152641	210086	195795	203328	171482	166837	3617765
GADVSU, Ludhiana	1727466	0	67289	31096	28195	57950	68829	102049	94699	84279	85399	2347251
OUAT, Bhubaneswar	1083326	0	0	52749	38754	51783	31685	18810	15212	100	0	1292419
ICAR-CARI (Broiler)	1335600	26695	17260	65557	48787	33830	43084	51388	38833	25038	46981	1733053
MPAUT, Udaipur	167046	32969	42365	102123	75604	78225	83471	76681	44772	31179	20108	754543
NDVSU, Jabalpur	138622	46066	9563	38981	58236	69407	51851	56432	58300	2961	51361	581780
AAU, Guwahati	32507	3402	10751	12731	24131	25111	28057	30720	44906	40095	44077	296488
CSKHPKVV, Palampur	40471	0	5330	20660	26715	36599	29617	44584	68597	54119	70333	397025
BAU, Ranchi	28407	2797	15248	12914	15755	15103	21235	25323	35185	18472	39812	230251
ICAR-RC, Agartala	56296	0	21285	15661	14193	14023	20913	25275	25275	31959	28561	253441
Total	**7493063**	**280396**	**356545**	**538418**	**528092**	**710889**	**854261**	**807869**	**798779**	**638088**	**654018**	**13660418**

Table xii. Revenue generated by different centres of AICRP on Poultry breeding (Rs. in Lakhs)

Centre	2012-2013	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	Total
KVASU, Mannuthy	27.66	44.74	33.79	39.82	64.26	53.43	35.01	19.3	18.78	15.52	352.31
AAU, Anand	16.5	33.28	19.97	20.43	26.72	18.41	26.16	21.73	24.91	33.48	241.59
SVVU, Hyderabad	5.98	8.18	14.2								28.36
KVAFSU, Bengaluru	29.83	37.02	32.69	33.79	33.79	54.98	52.34	58.47	49.69	46.67	429.27
GADVSU, Ludhiana	14.26	20.47	14.34	14.67	15.66	16.96	25.51	21.37	24.42	28.36	196.02
OUAT, Bhubaneswar	0.14	8.68	12	8.2	14	8.76	4.44	4.54	0.08	0	60.84
ICAR-CARI (Broiler)	-	-	-	30	30	35	8.03	29.79	0	0	132.82
MPAUT, Udaipur	11.02	9.44	13.97	11.33	20.69	20.33	14.9	18.7	6.34	30.57	157.29
NDVSU, Jabalpur	12.4	2.29	17.69	13.16	22.66	14.46	20.67	9.66	7.12	19.52	139.63
AAU, Guwahati	1.06	2.11	3.08	4.53	4.28	7.41	6.26	8.15	5.12	12.24	54.24
CSKHPKVV, Palampur	4.49	7.26	10.67	12.95	12.64	11.13	13.19	16.62	12.68	9.09	110.72
BAU, Ranchi	3.85	5	4.67	3.69	8.9	9.7	6.7	6.5	6.13	6.26	61.4
ICAR-RC, Agartala	0.65	8.38	9.95	9.52	7.98	10.54	10.26	11.57	20.86	5.45	95.16
Total	**127.84**	**186.85**	**187.02**	**202.09**	**261.58**	**261.11**	**223.47**	**226.4**	**176.13**	**207.16**	**2059.65**

Impact of the technologies

The major objective of AICRP on Poultry Breeding was to develop high yielding chicken varieties for commercial and rural poultry farming and to accomplish two major social obligations viz. minimizing the curse of the protein malnutrition and to ensure the supplemental income from poultry rearing / farming, thereby improving the economic status of mainly poor and landless farmers, weaker sections of the society. In addition, the adoption of technology by the target people will generate local and self-employment, restrict migration to the urban areas, develop cooperative network and better marketing, and encourage women empowerment.

Performance and profit realized from the varieties developed by AICRP on Poultry Breeding have been able to convince the policy planners and development agencies that this technology is highly relevant and practically feasible in the rural and tribal parts of India. Keeping in view the Govt of India identified these birds for the upliftment of the poor landless laborers in rural and tribal areas under the Backyard poultry. The publicity and impact generated through the print and electronic media along with technical support from the Directorate have been able to propagate the technology across all the states of the country. Several success stories documented by the team in videos speak itself about the worthiness of the technology and impact it had made on the life of the farmers throughout the country. Several queries from farmers during exhibitions of the germplasm are indicators of the popularity and performance of the varieties. Further, on-farm training of one week duration of the farmers and Veterinarians at the Directorate and AICRP centres have popularized and dessiminated the improved location specific chicken varieties to the nook and corners of the state and country. The project played a significant role in adopting the commercial poultry farming in the initial days where in the research work was concentrated on development of high yielding broiler and layer strains. The results of the project attracted many entrepreneurs in 1970s to poultry farming and subsequently it has become a multibillion industry in next 30-40 years.

A total of 136.60 lakhs of improved chicken germplasm was distributed to the farmers through 12 centres of AICRP on Poultry Breeding spread across the country. The faster growth rate and higher egg production up to 1.5 to 2 times of these birds as compared to native chickens which increased their acceptability amongst the farmers across the country. The project played a significant role in improving the nutritional security of the rural and tribal peoples in addition to the additional income. Another significant achievement of the project is the women empowerment, where in the backyard poultry is mostly managed by women farmers. AICRP on Poultry Breeding is the key point of chicks supply for improved germplasm in many parts of country. In the last ten years, annually, about 12.33 thousand stakeholders were benefited through these birds whereas, since inception about 273.21 thousand stakeholders were benefited. However, these numbers are mostly from late 80s and 90s onwards from where the commercial germplasm distribution started. The AICRP on Poultry Breeding is contributing an estimated amount of Rs. 25.44 crore/year to the Indian economy. Chicken meat and eggs are the major source of protein for millions of people in India especially, rural and tribal people. During the last 30-35 years, about 8388.45 tons of protein has been added to Indian food plate. In last ten years, the annual estimated protein quantity is about 378.72 tonnes from eggs and chicken meat produced from the project. Based on the last 10 years data, AICRP on poultry Breeding is contributing about 32.07 million eggs to total egg production and 656.21 tons of estimated chicken meat per annum. AICRP on Poultry Breeding has been contributing significantly to the rural economy by providing the nutritional security, improving the health condition and adding to the family income resulting in improved livelihood status of the rural and tribal people of the country.

Centrewise Achievements

1 Kerala Veterinary and Animal Scinces University, Mannuthy

All India Coordinated Research Project (AICRP) on Poultry Breeding was established in different agro-climatic zones in the country. A centre on layer breeding was established at KVASU, Mannuthy in 1976. Although, it was started in the year 1976, the strains IWN and IWP were selected based on the test-crossings made in the year 1973-74 and 1975-76. The parent stock of IWN and IWP were brought (1004 each of IWN and IWP) from ANGRAU, Hyderabad during 1978-79. In 1978, a third strain of White Leghorn namely 'F' was added with the purchase of 859 pullets and 220 cockerels from Kerala Agricultural University Poultry Farm. A fourth strain 'IWO' was included with the procurement of 830 female and 320 male chicks from the Hyderabad centre in December, 1980. As per the decisions taken in the seventh workshop held at Bangalore, 'IWO' and 'F' strains were dropped from this project in the year 1981. Since then, this centre has been involved in selective breeding of IWN and IWP strains for egg production through intra-population selection. The technical programme assigned to this centre with time to time modifications over the years was strictly adhered to in refining these populations.

The IWN and IWP germplasm available at this centre has undergone intense selection for egg production for 31 generations. The objective of this project during the initial years was to evolve a commercial strain capable of producing 200 standard sized eggs in 500 days, which underwent revisions during 1986, 1992, 2000 and 2008 to set higher targets of 250, 270, 290, 300 and 305 eggs, respectively with a layer house mortality of less than 1% per month. The target for egg size was fixed as 52g at 40 weeks of age in the XXVII workshop held at BAU, Ranchi.

The present objectives of the centre is to develop location-specific chicken variety suitable for Kerala region utilizing the native chicken and also to maintain the elite layer germplasm. This centre is working on IWN and IWP strains of White Leghorn along with Tellicherry chicken. These populations were subjected to selective breeding through intra-population selection (using individual, full sib and half sib information) only for egg production in the first two generations. The decline in egg size in these populations as well as in other stocks maintained at other AICRP centres prompted the need for the inclusion of egg weight also as independent culling level in the selection programme from third generation. The number of sires and dams used for breeding were 40 and 240 (1:6) respectively for many generations until S-13. In S-14, this was enhanced to 50 and 400 (1:8). From the very next generation (S-15), this was again modified as 50 and 300 respectively and is being followed till today. The population size for testing was 1500 pullets at housing in many generations from inception. The population size was further enhanced to 2500 from S-17 generation and further to a range of 2000 to 2500 from S-20 generation followed by a reduction to 900 from S-30 generation. The age at selection has also been revised periodically. These populations were selected for part-record egg production to 280 days (40 weeks) for several generations in the beginning until S-13 (except in S-9). The decline in residual egg production of strains maintained in different AICRP centres due to selection based on part period egg production over several generations called for an upward alteration of testing period to improve the persistency in these populations. For the very same reason, the testing period of IWN and IWP strains was also enhanced from 40 weeks to 60 weeks (S-18) to 64 weeks (S-19). Since then, the selection is being carried out based on egg production to 64 weeks. Rigorous selection for egg production for several generations brought about early maturity in these populations as a correlated response. As per the workshop decision, age at housing was also advanced from 20 weeks to 18 weeks (S-16) to 16 weeks (S-17) to enable the collection of complete egg production records. The natural pen mating with trap nesting followed in the earlier generations was discontinued with the introduction of artificial insemination in cages from S-16 generation in 1997 and the same is being followed. A genetic control of 200 birds is being maintained along with the selected populations from S-10 generation. The hatching eggs of control population were brought from ICAR-DPR, Hyderabad in every generation.

Based on the pure line performance over the years, IWN strain was identified as male line and IWP as female line for the hybrid cross. The N x P terminal hybrid of this centre (ILM90) has consistently exhibited excellent performance in the Random sample poultry performance tests conducted by the Government of India. In 1990, based on the consistent performance of strain-cross of this centre, this hybrid was released for commercial exploitation in the name of 'ILM90' (Indian Layer Mannuthy-1990). The crossbred was subsequently named as *Athulya* with a production potential of 315 eggs. *Athulya* is being propagated as a commercial layer chicken variety.

Achievements

The centre has evaluated the IWN and IWP strains for the last 33 generations up to 64 weeks of age. Intra-population selection method was practiced to select the parents using Osborne Index for higher egg production to 64 weeks of age. A sample of fertile eggs of a Layer control population obtained from ICAR-DPR, Hyderabad, was hatched and maintained along with the selected populations for measuring the genetic progress.

Selection records

The summary of selection records for the last five generations is presented in Table 1. The intensity of selection ranged from 0.27-0.58 σ in IWN and 0.29-0.61 σ in IWP. The effective population size varied from 160.2 -171.3 in IWN and 159.8 -171.2 in IWP line.

Table 1. Summary of selection records of IWN and IWP strains for last five generations

Strains	Gens.	Sires	Dams	Ne (Contributed)	SD in females	SI (σ)
IWN	S-28	50	278	169.5	14.40	0.58
	S-29	50	277	169.4	14.39	0.32
	S-30	50	298	171.3	10.55	0.27
	S-31	50	280	169.7	8.46	0.42
	S-32	49	219	160.2	12.14	0.48
IWP	S-28	50	275	169.2	17.90	0.49
	S-29	50	263	165.2	16.66	0.33
	S-30	50	297	171.2	10.26	0.29
	S-31	50	282	169.9	11.58	0.58
	S-32	50	199	159.8	16.88	0.61

Incubation records

The fertility (%) ranged from 65 to 98 % in IWN (Table 2) and 54 to 97 % in IWP (Table 3) lines over the generations. The hatchability (%) on fertile (FES) and total egg set (TES) in IWN varied from 63.2 % (S-0) to 92 % (S-6) and 41.2 % (S-0) to 86.6%(S-19), respectively (Table 2). The hatchability (%) on fertile and total egg set of IWP varied from 59.9 % (S-0) to 93.3% (S-4) and 32.3 % (S-0) to 87.5% (S-6) (Table 3), respectively. The trend of fertility and hatchability on FES was consistent over the generations with few exceptions, while many fluctuations were observed in hatchability on TES in both the lines. In general, the fertility and hatchability were comparable to the target set in the technical programme.

Table 2. Incubation records in IWN over the generations

Generation	Eggs set (Nos.)	Fertile eggs (Nos.)	Chicks hatched (Nos.)	Fertility (%)	Hatchability (%)	
					FES	TES
S-0	5210	3405	2151	65.2	63.2	41.2
S-1	7151	5405	4019	75.6	74.4	56.2
S-2	6270	5490	4598	87.6	83.8	73.3
S-3	5651	5064	4646	89.6	91.7	82.2
S-4	5959	5528	4843	93.2	87.6	81.7
S-5	3674	2964	2441	80.7	82.4	66.4
S-6	5121	4822	4447	94.2	92.2	86.2
S-7	8266	7883	7128	95.4	90.4	86.2

Generation	Eggs set (Nos.)	Fertile eggs (Nos.)	Chicks hatched (Nos.)	Fertility (%)	Hatchability (%)	
					FES	TES
S-8	7964	7414	6327	93.1	84.1	78.3
S-9	6679	6304	5717	94.3	91.0	85.6
S-10	6672	5725	4601	85.8	80.4	69.0
S-11	5468	5042	3766	89.6	76.9	68.9
S-12	7374	6500	5304	88.1	81.6	71.9
S-13	7031	6153	5050	87.5	82.1	71.8
S-14	9556	8551	6459	89.5	75.5	67.6
S-15	10350	6885	4679	66.5	68.0	45.2
S-16	17686	12001	8969	67.9	74.7	50.7
S-17	10144	9007	7557	88.8	83.9	74.5
S-18	8778	7304	6384	83.2	87.4	72.7
S-19	7409	6965	6030	94.1	81.4	86.6
S-20	7267		5808	94.06	86.5	81.4
S-21	8492		5565	82.1	79.8	65.6
S-22	8852		5765	82.5	82.9	68.4
S-23	8536		5516	98.37	83.68	82.38
S-24	8524		5016	95.85	81.16	77.79
S-25	9274		7461	96.03	84.08	80.74
S-26	9004		5580	96.51	67.66	62.06
S-27	8704		6111	97.15	74.24	72.13
S-28	6189		4561	93.97	80.02	75.20
S-29	5707		4244	84.72	87.96	74.55
S-30	6156		4865	88.55	89.83	79.60
S-31	6980		4903	88.86	86.66	70.94
S-32	5091		4038	89.13	87.17	79.32
S-33	3569		2496	80.10	85.84	65.24

FES: Fertile eggs set, TES: Total eggs set

Table 3. Incubation records in IWP over the generations

Generation	Eggs set (Nos.)	Fertile Eggs (Nos.)	Chicks hatched (Nos.)	Fertility (%)	Hatchability (%)	
					FES	TES
S-0	4483	2419	1449	53.9	59.9	32.3
S-1	5320	3860	2808	71.9	73.3	52.8
S-2	6109	5307	4474	86.9	83.4	72.4
S-3	5494	5021	4672	91.4	93.0	85.0
S-4	6124	5728	5345	93.5	93.3	87.3
S-5	3931	3231	2644	82.2	81.9	67.3
S-6	4693	4418	4108	94.1	93.0	87.5
S-7	6756	6402	5869	94.3	91.7	86.9
S-8	9522	8842	7714	92.8	87.2	81.0
S-9	7542	7265	6592	96.3	90.7	87.4
S-10	7039	6046	5276	85.9	87.3	75.0
S-11	4998	4474	3169	86.9	73.5	63.4

Generation	Eggs set (Nos.)	Fertile Eggs (Nos.)	Chicks hatched (Nos.)	Fertility (%)	Hatchability (%)	
					FES	TES
S-12	6967	5905	4821	84.8	81.6	69.2
S-13	6722	5832	4717	86.8	80.9	70.2
S-14	10354	9379	8428	90.6	89.9	81.4
S-15	9283	6627	4684	71.4	70.7	50.5
S-16	14371	9835	6966	68.4	70.8	48.5
S-17	10706	9562	7971	89.3	83.4	74.5
S-18	6942	5849	5224	84.3	89.3	75.3
S-19	7293	6685	5656	91.7	77.6	84.6
S-20	7293		5507	91.7	84.6	77.5
S-21	7292		4832	81.3	81.6	56.3
S-22	7305		4333	79.3	80.1	63.3
S-23	8854		5948	96.8	85.3	82.5
S-24	8395		5804	93.6	75.3	70.5
S-25	8833		6998	94.6	84.2	79.7
S-26	7089		5312	97.5	78.1	74.9
S-27	6816		5082	97.1	78.3	76.0
S-28	5953		4076	91.0	76.8	69.9
S-29	5794		4081	83.4	86.0	71.8
S-30	7017		5110	83.6	87.7	73.3
S-31	6404		4073	85.1	85.6	64.3
S-32	4631		3258	84.3	85.6	70.3
S-33	3320		1869	81.1	78.2	60.7

FES: Fertile eggs set, TES: Total eggs set

Mortality over the generations

The mortality of IWN and IWP strains were recorded in 1st week, 2-8 weeks, 9-20 weeks, 21-40 weeks of age up to S-17 generations (Table 4). The mortality of these two strains from S-18 to S-32 generations were recorded in the age groups of 0-8, 9-16, 17-40, 41-64 and 17-63 weeks and presented in Table 5.

The mortality pattern in both the lines was as per the standard permissible levels except in few generations in which high mortality rates were observed due to disease outbreaks. In the initial phases of selection, there was higher mortality due to Marek's disease, Avian Leucosis complex and Fatty liver degeneration. Marek's disease was a major problem in both IWN and IWP strains in S-3, S-6 and S-9 generations. The mortality rate due to some important diseases for IWN and IWP strains was also analysed, which shows that Marek's disease and Leukosis were major factors in increasing death rate in the initial phases of selection. The mortality due to Leukosis were controlled from S-7 generations and onward, while due to MD, the mortality rate was controlled from S-10 generations and onward in both strains. The mortality due to Fatty Liver disease was a problem up to S-5 generation.

Table 4. Mortality over generations up to S-17 generations

Strain	Generation	Age (wks)			
		0-1	2-8	9-20	21-40
IWN	S-1	2.3	0.4	0.6	3.8
	S-2	1.7	1.8	1.2	4.2
	S-3	1.1	1.6	0.6	12.1
	S-4	1.5	1.2	1.7	6.5
	S-5	1.4	1.3	0.8	1.5
	S-6	0.7	0.6	12.2	13.1
	S-7	2.6	1.9	8.6	2.8
	S-8	1.9	1.6	3.2	1.4
	S-9	1.9	3.9	2.9	11.8
	S-10	2.8	4.7	2.6	4.9
	S-11	1.9	1.3	1.3	0.1
	S-12	2.5	2.8	2.6	2.9
	S-13	0.4	2.9	4.3	4.6
	S-14	1.7	1.8	2.7	3.8
	S-15	2.5	59.7	7.8	6.2
	S-16	5.6	6.8	1.9	7.4
	S-17	2.4	31.4	3.8	7.1

Strain	Generation	Age (wks)			
		0-1	2-8	9-20	21-40
IWP	S-1	5.2	0.9	1.5	1.9
	S-2	2.4	1.6	3.4	2.5
	S-3	1.6	1.0	1.4	5.3
	S-4	2.1	1.3	4.7	4.7
	S-5	1.7	0.8	1.0	3.0
	S-6	1.3	0.4	10.8	13.7
	S-7	3.6	1.8	9.6	6.9
	S-8	2.5	0.7	2.4	2.4
	S-9	1.3	1.6	3.9	9.1
	S-10	3.3	5.7	2.0	3.9
	S-11	2.1	0.9	2.2	0.1
	S-12	2.4	1.9	2.6	1.4
	S-13	2.2	2.1	2.3	4.9
	S-14	2.4	1.8	3.1	3.8
	S-15	2.6	43.9	3.7	5.0
	S-16	7.4	4.9	1.1	5.8
	S-17	2.4	32.7	3.6	5.9

Table 5. Mortality at different ages over the generations from S-18 onwards

Gen.	Strain	0-8 wks	9-16 wks	17-40 wks	41-64 wks
S-18	IWN	3.60	0.30	3.40	3.80
	IWP	1.60	1.30	2.40	3.30
S-19	IWN	1.045	0.935	2.96	3.50
	IWP	1.17	0.815	3.44	2.72
	Control	1.67	0.37	1.50	0.51
S-20	IWN	2.10	0.60	3.23	1.775
	IWP	1.30	0.695	2.81	1.45
	Control	4.9	0.91	1.48	0.00
S-21	IWN	1.25	0.19	2.38	3.00
	IWP	3.24	0.29	2.20	2.45
	Control	1.57	0.30	1.16	1.95
S-22	IWN	1.17	1.08	4.12	-
	IWP	1.33	1.56	5.26	-
	Control	0.52	0.56	1.78	-
S-23	IWN	2.35	0.54	2.31	2.05
	IWP	1.33	0.81	3.94	3.82
	Control	6.23	9.61	3.90	4.57
S-24	IWN	1.96	0.71	3.72	-
	IWP	1.02	0.56	4.01	-
	Control	1.21	0.00	4.15	-

Gen.	Strain	0-8 wks	9-16 wks	17-40 wks	41-64 wks
S-25	IWN	3.04	0.94	-	3.96
	IWP	3.83	1.23	-	6.45
	Control	1.75	3.20	-	3.89
S-26	IWN	7.91	3.35	3.21	-
	IWP	5.19	3.27	4.48	-
	Control	5.67	4.17	1.10	-
S-27	IWN	5.22	0.64	3.04	-
	IWP	3.93	0.60	4.63	-
	Control	22.22	7.14	0	-
S-28	IWN	6.57	7.96	6.26	
	IWP	4.97	0.22	5.00	
	Control	2.87	7.03	5.33	
S-29	IWN	5.3	2.41	2.38	
	IWP	5.8	1.39	3.98	
	Control	5.4	3.82	7.62	
S-30	IWN	4.89	1.45	6.75	
	IWP	2.09	2.35	7.70	
	Control	1.20	4.40	5.40	
S-31	IWN	6.57	4.05	3.43	
	IWP	6.04	3.35	5.87	
	Control	2.65	0	3.75	
S-32	IWN	3.97	0.97	2.29	
	IWP	5.82	1.41	3.67	
	Control	4.59	0.00	5.48	

Performance

The growth and production traits were recorded and analysed over the generations. The impact of long-term selection was observed in all the traits in favourable direction.

Age at sexual maturity (ASM)

The details of ASM in IWN and IWP lines over the generations are presented in Table 6. The average age at sexual maturity has reduced over the generations from 177.34 (S-1) to 129.4 days (S-33) in IWN and from 178.07 (S-1) days to 132.5 days (S-33) in IWP strain. ASM has gradually reduced in positive direction over the years as a correlated response to the selection.

Table 6. Age at Sexual Maturity (days) over generations

Gen.	IWN		IWP	
	Nos.	ASM, days	Nos.	ASM, days
S-1	584	177.3±0.74	428	178.1±0.70
S-2	1322	161.3±0.25	910	154.7±0.32
S-3	1297	159.3±0.30	1391	156.1±0.27
S-4	1270	165.2±0.34	1302	161.3±0.34
S-5	1356	154.1±0.28	1352	152.5±0.27
S-6	847	161.0±2.17	985	158.0±0.44
S-7	1403	155.1±0.26	1377	151.6±0.25
S-8	1385	157.5±0.34	1350	156.7±0.32
S-9	1203	157.5±0.44	1115	164.6±0.39
S-10	1607	148.7±0.22	1520	148.3±0.27
S-11	1557	153.1±0.33	1511	153.3±0.32
S-12	983	157.4±0.52	874	156.3±0.42
S-13	992	162.8±0.39	829	153.7±0.32
S-14	1266	153.2±0.37	1310	148.6±0.45
S-15	710	167.3±0.64	1328	159.2±0.39
S-16	1304	151.7±0.09	1429	145.2±0.10
S-17	1640	153.3±0.04	1460	150.9±0.01
S-18	2445	148.9±0.03	2508	148.3±0.07
S-19	2392	151.4±0.09	2115	144.5±0.06
S-20	2117	143.9+0.04	2103	137.6+0.04
S-21	2135	139.9±0.02	1900	135.6± 0.03
S-22		138.0		136.0
S-23		154.2		152.7
S-24	2196	136.6±0.30	2136	132.0±0.27
S-25	1580	146.4±0.24	1598	143.8±0.21
S-26	1684	138.8±0.23	1679	139.4±0.21
S-27	1718	139.0±0.68	1757	139.1±0.18
S-28	1045	144.5±0.43	1030	139.7±0.42
S-29	1009	141.4±0.20	1006	139.9±0.88
S-30	619	139.6±0.39	753	135.4±0.46
S-31	894	144.4±0.32	889	139.5±0.31
S-32	895	142.0±0.27	879	140.8±0.29
S-33	843	129.4±0.33	855	132.5±0.33

Growth

The body weights at 20 weeks (up to S-17), at 16 weeks (from S-18) and 40 weeks of age were recorded in layer pure lines and presented in Table 7. The average body weight at 20 weeks of age (BW20) increased over the generations in both the strains. The BW20 ranged from 1162 (S-1) to 1357 (S-16) g in IWN and 1164 (S-1) to 1449 (S-16) g in IWP lines. The body weight at 16 weeks of age (BW16) was recorded from S-18 generation instead of BW20 as the ASM reduced and housing was done at 16 weeks of age. The BW16 ranged between 960.8 (S-32) and 1216 (S-24) in IWN and 926.4 (S-32) to 1217 (S-24) in IWP lines. The BW16 was maintained between 1.0 to 1.2 kg in both the lines as per the breed standards of White Leghorn lines. Body weight at 40 weeks of age (BW40) was maintained between 1.4 to 1.7 kg in IWN and 1.4-1.8 kg in IWP line.

Table 7. Body weights (g) at different ages over the generations

Gen.	IWN				IWP			
	Nos.	BW20	Nos.	BW40	Nos.	BW20	Nos.	BW40
S-1	584	1162±5.30	584	1602±7.31	428	1164±5.65	428	1681±9.35
S-2	1322	1180±3.30	1322	1393±3.70	910	1277±4.01	910	1432±5.22
S-3	1297	1201±2.54	1297	1506±4.31	1391	1228±2.64	1391	1644±8.75
S-4	1270	1105±3.60	1270	1478±4.00	1302	1185±2.93	1302	1488±4.00
S-5	1356	1342±2.97	1356	1507±3.59	1352	1396±3.17	1352	1585±3.98
S-6	847	1304±7.40	847	1471±5.31	985	1373±4.47	985	1498±5.07
S-7	1403	1353±3.22	1403	1591±11.63	1377	1413±3.50	1377	1643±4.23
S-8	1385	1220±2.91	1385	1445±3.33	1350	1254±3.00	1350	1518±3.43
S-9	1203	1212±3.18	-	-	1115	1205±3.12	-	-
S-10	1607	1332±3.00	1607	1623±5.00	1520	1405±3.00	1520	1752±4.60
S-11	1557	1310±3.20	1557	1567±3.80	1511	1350±3.80	1511	1676±5.30
S-12	983	1192±4.20	983	1494±5.43	874	1253±4.10	874	1584±5.40
S-13	992	1183±5.30	992	1557±6.00	829	1292±4.50	829	1739±7.00
S-14	1266	1308±3.53	1266	1533±5.40	1310	1339±3.53	1310	1566±4.78
S-15	710	1248±6.00	710	1557±6.00	1328	1327±4.00	1328	1739±7.00
S-16	1304	1357±2.30	1304	1662±1.60	1429	1449±2.30	1429	1757±1.30
S-17	1643	1333±1.20	1643	1688±1.70	1460	1366±0.90	1460	1774±2.20
*		**BW16**				**BW16**		
S-18	2445	1023±0.60	2445	1696±0.70	2508	1006±0.60	2508	1820±1.30
S-19	2438	1097±0.20	2364	1563±0.90	2150	1135±0.40	2090	1639±1.00
S-20	2120	1116±0.60	2098	1584+0.70	2112	1131±0.08	2081	1651+1.00
S-21	2135	1176±0.30		1620	1900	1190±0.60		1686
S-22				1618				1689
S-23				1560				1587
S-24	2232	1216±2.4	2155	1705+3.9	2166	1217±2.0	2106	1732+4.12
S-25	1585	1015±3.20	1551	1499±3.74	1607	988±2.94	1563	1513±3.78
S-26	1703	1062±3.03	1647	1613±4.59	1693	1073±2.67	1642	1700±5.29
S-27	1736	1118±2.94	1682	1446±4.16	1776	1133±2.18	1702	1485±4.21
S-28	1051	1037±2.62	1026	1561±6.07	1034	1054±2.72	1030	1530±5.79
S-29	1009	1051±2.54	973	1447±5.27	1006	1042±2.75	984	1427±4.52
S-30	622	1081±2.77	580	1497±5.73	753	1103±2.92	695	1500±5.03
S-31	896	1048±3.21	885	1432±4.46	901	1082±2.95	845	1396±4.94
S-32	900	960.8±2.5	788	1504±5.49	879	926.4±2.63	843	1437±6.11

Egg production

The details of egg production up to 40 weeks of age are presented in Table 8. The egg production up to 40 weeks of age (EP40) has increased significantly in both IWN and IWP lines. In IWN, the EP40 increased from an initial production of 58 eggs to 128 (S-32) and in IWP the production increased from 66 (S-1) to 125 eggs (S-32). The selection for higher egg production has resulted in significant increase in production over the generations in both the strains initially as a result of direct response to selection and later as a result of correlated response as the selection criterion was changed to higher 64-week egg production in later stages. The trend of egg production up to 60 weeks of age was analysed from S-15 to S-18 generations and an increase in the part period egg production (EP60) was observed in both the strains.

Egg production up to 64 weeks of age was the selection criterion from S-16 generation onwards. The EP64 increased significantly over the years in both the lines. In IWN, EP64 increased from 190 to 264 eggs in IWN and from 202 to 261 eggs as a direct response to the selection. In the present generation (S-32) the hen housed egg production to 64 weeks of age was 262.4±1.28 and 249.6±1.5 eggs in IWN and IWP lines, respectively.

Table 8. Egg production (hen housed) to 40 (EP40) and 64 (EP64) weeks of age over the generations (Nos)

Gen.	IWN				IWP			
	Nos.	EP40	Nos.	EP64	Nos.	EP40	Nos.	EP64
S-1	584	58.34±0.75			428	66.05±0.77		
S-2	1322	74.76±0.57			910	82.67±0.59		
S-3	1297	82.62±0.85			1391	84.29±0.48		
S-4	1270	86.73±0.47			1302	84.88±0.47		
S-5	1356	93.87±0.49			1352	96.78±0.43		
S-6	847	90.59±0.65			985	93.70±0.52		
S-7	1403	97.07±0.35			1377	98.25±0.36		
S-8	1358	90.90±0.34			1350	94.35±0.33		
S-9	1203	48.73±0.39			1115	44.14±0.38		
S-10	1607	103.2±0.35			1520	101.70±0.46		
S-11	1557	88.98±0.47			1511	89.54±0.43		
S-12	983	88.00±0.50			874	89.33±0.54		
S-13	992	88.05±0.54			829	96.24±0.61		
S-14	1266	92.93±0.51			1310	95.66±0.59		
S-15	710	93.61±0.80	710	191.2±1.40	1328	97.48±0.49	1328	202.6±0.91
S-16	1304	100.4±0.09	1128	193.2±0.09	1429	105.3±0.07	939	195.3±0.10
S-17	1643	99.80±0.48	1643	180.3±0.64	1460	100.7±0.31	1460	178.9±0.46
S-18	2445	103.1±0.05	2445	203.7±0.10	2508	107.1±0.05	2508	206.0±0.11
S-19	2408	102.8±0.09	2410	221.0±0.19	2127	107.2±0.19	2133	229.3±0.22
S-20	2117	116.0±0.03	2119	237.1±0.10	2104	121.2±0.02	2105	246.4±0.04
S-21		123.3		246.6		124.0		247.1
S-22		117.9		244.9		115.4		231.0
S-23		110.7		248.3		106.1		234.5
S-24	2199	127.2±0.45		251.7	2146	124.5±0.53		237.8
S-25	1585	120.5±0.50	1722	264.8±2.86	1607	118.2±0.55	1767	255.1±1.31
S-26	1703	124.0±0.61	1703	251.4±1.46	1693	122.2±0.58	1693	254.1±1.31
S-27	1722	128.0±1.73	1722	264.8±2.86	1767	124.6±0.60	1767	255.1±1.31
S-28	1051	122.4±0.73	1051	256.7±1.52	1034	123.3±0.83	1034	261.4±1.4
S-29	1009	122.7±0.36	1009	255.0±1.24	1006	121.0±0.40	1006	261.3±1.13
S-30	622	120.2±0.99	622	245.7±2.57	753	124.8±0.88	753	247.8±2.23
S-31	902	121.2±0.65	902	263.1±1.46	847	124.4±0.74	902	247.7±2.44
S-32	893	127.9±0.50	893	262.4±1.28	879	125.5±0.63	879	249.6±1.5

*S-9: 32 weeks egg number, #S-15, S-16 & S-18: 60 weeks egg production, %S-17: 56 weeks egg production

Egg weight

The egg weights recorded at different ages in IWN and IWP lines are presented in Table 9. In the initial stages of the project, egg weights were recorded at 32 (EW32) and 40 (EW40) weeks of age, subsequently 28 (EW28) and 64 (EW64) week egg weights were recorded. The EW32 in IWN and IWP strains increased from S-9 to S-15 generations. This might be as a result of selection as higher egg weight birds were selected by independent culling levels. The EW28 was recorded instead of EW32 from S-16 onwards. EW28 ranged from 47 to 52 g in IWN and 48 to 53 g in IWP lines over the generations. EP40 showed an increasing trend in both the lines in earlier generations and subsequently decreased. This might be due to the selection criterion followed as the selection is based on independent culling levels for egg number and egg weight in earlier generations. Subsequently, Osborn index selection method was used for higher egg numbers at 64 weeks of age. As egg number and egg weight are negatively correlated traits, this led to a reduction in egg weight.

Table 9. Egg weights (EW) at different ages in IWN and IWP strains (g)

Gen.	IWN			IWP		
	EW28	EW40	EW64	EW28	EW40	EW64
S-1		51.99±0.15			51.80±0.16	
S-2		51.51±0.09			51.70±0.11	
S-3		50.94±0.11			52.12±0.08	
S-4		50.63±0.11			50.80±0.08	
S-5		51.05±0.08			52.17±0.09	
S-6		52.77±0.77			52.26±0.15	
S-7		52.02±0.07			52.73±0.08	
S-8		50.64±0.08			52.18±0.09	
S-9		47.32±0.09*			47.55±0.09*	
S-10		51.00±0.07			51.60±0.09	
S-11		52.27±0.08			53.11±0.09	
S-12		53.15±0.11			54.19±0.12	
S-13		53.40±0.10			53.18±0.17	
S-14		53.12±0.09			52.12±0.09	
S-15		52.61±0.13			52.60±0.09	
S-16	48.29±0.03	52.74±0.02		48.24±0.03	52.49±0.02	
S-17	47.24±0.01	50.66±0.03		47.88±0.002	50.97±0.04	
S-18	49.69±0.01	53.60±0.01		48.76±0.02	53.10±0.01	
S-19	50.47±0.02	54.04±0.02		50.20±0.01	54.14±0.02	
S-20	50.63±0.01	54.26±0.02		50.42±0.01	54.01±0.02	
S-21	51.44±0.01	54.9		51.34±0.01	54.7	
S-22		53.4			53.5	
S-23		54.5			55.0	
S-24	50.02±0.07	55.23±0.08		50.42±0.07	55.02±0.09	
S-25	48.45±0.08	51.33±0.09	55.73±0.10	48.46±0.08	52.76±0.10	57.08±0.12
S-26	51.48±0.09	53.45±0.09	54.09±0.10	53.25±0.09	55.06±0.09	56.63±0.11
S-27	48.98±0.43	51.91±0.48	55.03±0.49	49.74±0.08	52.09±0.09	56.53±0.11
S-28	48.00±0.10	52.16±0.10	54.16±0.37	48.22±0.09	51.46±0.11	55.30±0.13
S-29	48.00±0.10	52.16±0.10	54.16±0.37	48.39±0.09	52.13±0.09	53.58±0.11
S-30	48.11±0.13	52.03±0.16	52.56±0.17	48.62±0.11	52.11±0.15	53.80±0.18
S-31	50.29±0.11	50.99±0.11	51.89±0.13	50.05±0.12	50.44±0.13	53.73±0.16
S-32	49.47±0.10	51.61±0.11	51.83±0.17	48.91±0.1	51.61±0.11	51.76±0.21


Figure 1: White Leghorn strains (IWN & IWP)

Egg quality traits

The results of egg quality traits for IWN and IWP strains over the generations are presented in Table 10. The Haugh unit has been increased over the years. However, other egg quality traits have not witnessed any major change.

Table 10. Egg quality traits in IWN and IWP strains

Strain	Gen.	Albumen Index	Yolk Index	Shell thickness (mm)	Haugh unit
IWN	S-1	0.08±0.002	0.41±0.001	0.36±0.002	78.1±0.55
	S-2	0.10±0.002	0.42±0.002	0.33±0.001	84.0±0.52
	S-3	0.08±0.001	0.42±0.002	0.33±0.002	76.1±0.62
	S-4	0.08±0.002	0.40±0.003	0.34±0.002	77.1±0.67
	S-5	0.10±0.002	0.45±0.003	0.35±0.003	86.7±0.67
	S-6	0.09±0.002	0.42±0.001	0.34±0.001	88.7±0.67
	S-7	0.13±0.002	0.50±0.002	0.36±0.002	93.9±0.64
	S-8	0.11±0.002	0.50±0.003	0.36±0.002	92.8±0.57
	S-10	0.09±0.008	0.44±0.003	0.34±0.002	78.9±1.03
	S-11	0.12±0.002	0.48±0.008	0.38±0.002	92.6±0.57
	S-12	0.10±0.002	0.34±0.003	0.45±0.002	87.1±0.65
	S-13	0.11±0.002	0.35±0.002	0.44±0.002	91.4±0.64
	S-14	0.11±0.002	0.36±0.003	0.43±0.002	90.3±0.65
	S-15	0.11±0.002	0.37±0.003	0.44±0.002	91.4±0.67
	S-16	0.11±0.002	0.43±0.003	0.26±0.003	88.3±1.40
	S-17	0.10±0.002	0.46±0.002	0.31±0.001	87.4±0.68
	S-18	0.12±0.002	0.43±0.002	0.34±0.003	91.54±0.47
	S-19	0.12±0.002	0.46±0.007	0.34±0.002	97.20±0.60
	S-20	0.14±0.003	0.45±0.006	0.35±0.002	98.2±0.72
	S-24	0.106±0.002	0.40±0.003	0.33±0.003	88.8±0.77
	S-25	0.11±0.002	0.44±0.003	0.32±0.002	88.61±0.81
	S-26	0.13±0.002	0.43±0.002	0.29±0.002	94.81±0.636
	S-27	0.11±0.002	0.42±0.003	0.29±0.005	87.63±0.61
	S-28	-	-	0.29±0.005	74.32±0.61

Strain	Gen.	Albumen Index	Yolk Index	Shell thickness (mm)	Haugh unit
IWP	S-1	0.07±0.003	0.42±0.001	0.34±0.001	76.0±0.39
	S-2	0.10±0.002	0.42±0.002	0.33±0.001	84.0±0.52
	S-3	0.08±0.002	0.44±0.002	0.33±0.002	74.3±0.06
	S-4	0.07±0.002	0.43±0.003	0.33±0.002	75.0±0.74
	S-5	0.11±0.012	0.45±0.003	0.33±0.003	75.0±0.74
	S-6	0.09±0.001	0.43±0.003	0.33±0.008	86.4±0.79
	S-7	0.11±0.002	0.51±0.002	0.35±0.001	89.9±0.74
	S-8	0.12±0.003	0.32±0.001	0.36±0.002	90.0±0.52
	S-10	0.11±0.003	0.43±0.004	0.37±0.006	88.6±0.52
	S-11	0.09±0.001	0.36±0.001	0.37±0.002	81.7±0.74
	S-12	0.09±0.002	0.45±0.003	0.38±0.004	82.7±0.68
	S-13	0.11±0.002	0.37±0.003	0.39±0.002	88.6±0.57
	S-14	0.10±0.001	0.38±0.002	0.40±0.002	86.6±0.58
	S-15	0.10±0.001	0.38±0.002	0.44±0.002	88.6±0.57
	S-16	0.10±0.002	0.44±0.002	0.34±0.007	84.1±1.90
	S-17	0.08±0.002	0.44±0.002	0.38±0.001	84.1±0.94
	S-18	0.10±0.002	0.45±0.005	0.34±0.004	86.25±0.61
	S-19	0.09±0.002	0.45±0.009	0.34±0.002	87.63±0.93
	S-20	0.12±0.002	0.44±0.001	0.34±0.002	92.45±0.76
	S-24	0.082±0.003	0.373±0.009	0.333±0.006	81.27±0.84
	S-25	0.09±0.002	0.41±0.003	0.31±0.002	82.77±1.01
	S-26	0.09±0.002	0.41±0.002	0.30±0.002	84.51±0.794
	S-27	0.11±0.001	0.41±0.003	0.31±0.003	81.32±0.67
	S-28	-	-	0.29±0.003	70.16±0.67

S-9, S-21- 23 not recorded

Selection differential and realized phenotypic response

Selection differential (SD) and realized response (RR) for IWN and IWP lines were measured for 19 generations (S-2 to S-20) and presented in Table 11. The SD for EP40 in different generations varied between 5.3 to 22.1 eggs, while RR varied from –14.2 to 11.4 in IWN. The SD and RR for EW40 varied from –2.0 to 2.3 and –2.3 to 2.0, respectively in IWN. The SD and RR of ASM for IWN strain in different generations varied from –7.5 to 1.0 and –10.9 to 6.9, respectively. The SD of EP40, EW40 and ASM in IWP over generations varied from 4.6 to 27.5, –1.8 to 2.1 and –9.3 to –0.3 days, respectively. The corresponding values of RR were -11.4 to 12.5, –1.3 to 2.0 and -10.9 to 7.0, respectively in IWP line.

Table 11. Selection differential and realized response in IWN and IWP strains.

Gen.	IWN						IWP					
	EP40		EW40		ASM		EP40		EW40		ASM	
	SD	RR	SD	RR	SD	RR	SD	RR	SD	RR	SD	RR
S-2	22.1	11.4	-0.09	-0.5	-2.8	-2.5	27.5	3.3	-0.3	0.4	-4.3	-
S-3	20.7	6.4	0.7	-0.4	-5.6	6.0	16.1	0.8	0.4	-1.3	-4.8	5.8
S-4	14.7	8.6	1.0	0.4	-7.5	-10.9	14.3	12.5	0.8	1.4	-5.9	-10.9
S-5	8.6	2.5	2.3	1.8	-3.3	6.9	7.6	1.4	2.1	0.1	-2.5	5.5
S-6	5.3	-2.5	2.3	1.8	-3.3	6.9	6.7	3.8	-1.8	0.5	-9.3	-6.4

Gen.	IWN						IWP					
	EP40		EW40		ASM		EP40		EW40		ASM	
S-7	13.5	-	0.0	-	-6.1	-	12.5	-	0.6	-	-4.8	-
S-8	8.4	-	0.0	-	-6.6	-	10.5	-	-0.6	-	-8.0	-
S-9	8.7	1.3	1.2	0.4	-6.2	-1.6	7.1	1.6	1.0	0.2	-6.8	-1.7
S-10	8.2	1.2	0.8	0.3	-2.0	-0.7	9.8	0.8	0.9	0.1	-5.0	-1.6
S-11	7.9	-14.2	-1.7	1.3	-2.5	4.4	8.5	-11.4	-1.0	1.5	-3.0	7.0
S-12	9.5	1.6	0.3	2.0	-6.7	-4.2	11.7	3.8	-0.9	0.8	-5.2	-2.7
S-13	12.9	3.4	-2.0	-2.3	-7.3	0.6	10.8	-0.9	-1.0	-0.1	-2.7	2.5
S-14	10.2	-2.7	-0.5	1.5	-3.5	3.8	9.8	-1.0	-0.8	0.2	-4.4	-1.7
S-15	-		1.0	1.5	-3.9	-0.43			1.2	2.0	-1.7	2.7
S-16	8.1		1.2	0.2	-0.2	3.7	7.3		0.3	-0.9	-0.9	0.8
S-17	15.9	7.8	1.5	0.3	-2.4	-2.2	14.7	7.4	1.4	1.1	-1.2	-0.3
S-18	10.1	-5.8	1.7	0.2	-1.8	0.6	11.1	-3.6	1.2	-0.2	-0.5	0.7
S-19	11.0	0.9	1.8	0.1	1.0	2.8	9.6	-1.5	1.7	0.5	-0.3	0.2
S-20	6.6	-4.4	0.4	-1.4	-0.7	1.7	4.6	-5.0	1.1	-0.6	-0.4	0.7

Genetic parameters over generations

Heritability

The detailed heritability estimates from various components from the first generation to the present generation (S-32) for different economic traits of importance are provided in Tables 12, 13, 14 15 and 16. Heritability of ASM of IWN and IWP strains was moderate to high over the generations except a few generations, wherein the heritability was low. However, in some of the generations, the standard errors of heritability were high indicating less precise estimate for ASM and it was true for other traits also. The heritability estimates for BW20 and BW40 was moderate to high over the generations in both the lines substantiating the fact that body weight is a highly heritable trait in chicken. Heritability of BW16 of both the strains from all components was moderate to high over generations.

Heritability estimates of part period egg productions, EP40 and EP64 over generations were moderate to low. Egg production traits are low heritable traits in chicken which was observed in these lines as well. The heritability showed a decreasing trend up to 30th generation and increasing trend from 31 generation. This might be due to the increased variability in the populations through addition of new populations from other centres. Also, due to switching over of selection from EP40 to EP64, the heritability of EP40 has increased in the last two generations.

Heritability estimate of EW28 was estimated from S-16 generation for both the strains, while, the heritability of EW40 was estimated from S-1 generation, since inception of the project. Heritability of EW28 and EW40 over the generations was found to be moderate to high and maintained over the generations. No definite positive or negative trend over the generations was observed for both the strains.

Table 12. Trend of heritability estimates for ASM from different components over the last 32 generations

Gen.	IWN			IWP		
	Sire	Dam	Sire + Dam	Sire	Dam	Sire + Dam
S-1	0.28±0.12	-0.10±0.15	0.09±0.08	0.36±0.17	-0.10±0.21	0.13±0.11
S-2	0.04±0.06	0.32±0.11	0.18±0.05	0.42±0.14	0.24±0.12	0.33±0.08
S-3	0.55±0.14	0.44±0.11	0.40±0.09	0.21±0.08	0.18±0.09	0.19±0.05
S-4	0.55±0.16	0.25±0.09	0.40±0.09	0.62±0.17	0.26±0.09	0.44±0.09
S-5	0.46±0.12	0.05±0.07	0.25±0.07	0.48±0.14	0.29±0.09	0.38±0.08
S-6	0.44±0.16	0.33±0.14	0.38±0.11	0.40±0.13	0.18±0.11	0.23±0.10
S-7	0.26±0.10	0.31±0.09	0.29±0.07	0.23±0.08	0.18±0.09	0.21±0.07
S-8	0.30±0.10	0.13±0.08	0.22±0.06	0.11±0.06	0.20±0.09	0.15±0.06
S-9	0.16±0.08	0.26±0.10	0.21±0.06	0.13±0.07	0.26±0.11	0.19±0.06
S-10	0.30±0.01	0.35±0.09	0.32±0.06	0.23±0.09	0.32±0.10	0.28±0.06
S-11	0.29±0.10	0.20±0.09	0.24±0.06	0.13±0.06	0.08±0.08	0.10±0.04
S-12	0.26±0.10	0.14±0.12	0.20±0.07	0.50±0.16	0.25±0.13	0.38±0.09
S-13	0.47±0.14	0.06±0.11	0.26±0.08	0.19±0.10	0.24±0.14	0.22±0.07
S-14	0.28±0.09	-0.01±0.08	0.13±0.04	0.28±0.10	0.17±0.09	0.23±0.06
S-15	0.24±0.13	0.25±0.18	0.24±0.09	0.12±0.06	0.06±0.10	0.09±0.05
S-16	0.28±0.10	0.16±0.09	0.22±0.06	0.13±0.06	0.14±0.08	0.14±0.04
S-17	0.18±0.07	0.04±0.07	0.11±0.04	0.26±0.08	-0.01±0.08	0.12±0.05
S-18	0.28±0.08	0.26±0.06	0.27±0.05	0.25±0.08	0.30±0.07	0.27±0.05
S-19	0.20±0.06	0.19±0.06	0.20±0.04	0.37±0.10	0.13±0.06	0.25±0.05
S-20	0.28±0.08	0.30±0.07	0.29±0.05	0.32±0.09	0.12±0.06	0.22±0.05
S-24	0.34±0.09	0.07±0.05	0.206±0.04	0.315±0.08	0.173±0.06	0.244±0.03
S-26	0.236±0.073	0.306±0.080	0.271±0.046	0.310±0.0897	0.340±0.087	0.325±0.052
S-27	0.192±0.064	0.250±0.075	0.221±0.042	0.202±0.067	0.560±0.091	0.381±0.053
S-28	0.33±0.11	0.72±0.14	0.53±0.08	0.07±0.06	0.55±0.13	0.31±0.07
S-29	0.061±0.060	0.322±0.125	0.191±0.057	0.346±0.114	0.231±0.119	0.288±0.063
S-30	0.075±0.100	0.591±0.196	0.033±0.092	0.168±0.102	0.00±0.00	0.084±0.065
S-31	0.433±0.142	0.406±0.149	0.419±0.078	0.464±0.143	0.043±0.132	0.253±0.067
S-32	0.35±0.12	0.32±0.14	0.34±0.07	0.14±0.08	0.02±0.13	0.08±0.05

S-21- 23, S-25 not estimated

Table 13. Trend of heritability estimates for egg production up to 40 weeks (EP40) from different components over the last 32 generations

Gen.	IWN			IWP		
	Sire	Dam	Sire + Dam	Sire	Dam	Sire + Dam
S-1	0.33±0.15	0.21±0.17	0.27±0.10	0.60±0.22	0.06±0.21	0.33±0.13
S-2	0.10±0.07	0.29±0.10	0.19±0.05	0.47±0.17	0.17±0.11	0.32±0.08
S-3	0.23±0.07	-0.18±0.07	0.03±0.05	0.13±0.06	0.26±0.10	0.20±0.05
S-4	0.39±0.12	0.30±0.10	0.34±0.07	0.41±0.12	0.09±0.08	0.25±0.07
S-5	0.31±0.10	0.14±0.08	0.22±0.06	0.40±0.12	0.14±0.08	0.27±0.07
S-6	0.28±0.12	0.18±0.15	0.20±0.11	0.29±0.12	0.31±0.13	0.30±0.10
S-7	0.38±0.12	0.22±0.09	0.30±0.07	0.28±0.09	0.06±0.08	0.17±0.06

Gen.	IWN			IWP		
	Sire	Dam	Sire + Dam	Sire	Dam	Sire + Dam
S-8	0.16±0.07	0.22±0.09	0.30±0.07	0.26±0.09	0.20±0.09	0.23±0.06
S-9	0.32±0.11	0.15±0.09	0.24±0.06	0.18±0.08	0.22±0.11	0.20±0.06
S-10	0.28±0.09	0.14±0.07	0.21±0.05	0.41±0.12	0.08±0.07	0.24±0.06
S-11	0.28±0.09	0.11±0.08	0.20±0.06	0.15±0.06	0.09±0.08	0.12±0.05
S-12	0.28±0.11	0.19±0.11	0.24±0.07	0.13±0.10	0.58±0.17	0.35±0.08
S-13	0.30±0.10	-0.10±0.10	0.10±0.06	0.03±0.06	0.09±0.13	0.06±0.06
S-14	0.26±0.09	0.08±0.08	0.17±0.06	0.07±0.06	0.29±0.10	0.18±0.05
S-15	0.20±0.13	0.32±0.19	0.26±0.09	0.10±0.06	0.36±0.12	0.23±0.06
S-16	0.13±0.06	0.10±0.07	0.06±0.04	0.04±0.03	0.03±0.07	0.01±0.03
S-17	0.02±0.04	0.18±0.09	0.10±0.04	0.04±0.04	0.03±0.08	0.02±0.04
S-18	0.04±0.03	0.22±0.06	0.13±0.03	0.01±0.03	0.20±0.06	0.11±0.03
S-19	0.07±0.03	0.04±0.05	0.06±0.03	0.08±0.04	0.07±0.06	0.08±0.03
S-20	0.29±0.09	0.34±0.08	0.31±0.05	0.26±0.07	0.12±0.06	0.19±0.04
S-24	0.24±0.07	0.30±0.07	0.27±0.04	0.18±0.06	0.15±0.06	0.17±0.03
S-26	0.11±0.05	0.07±0.06	0.09±0.03	0.02±0.03	0.27±0.08	0.15±0.04
S-27	0.03±0.03	0.05±0.06	0.04±0.03	0.09±0.05	0.35±0.09	0.22±0.05
S-28	0.09±0.07	0.11±0.12	0.10±0.05	0.24±0.099	0.18±0.12	0.21±0.06
S-29	0.09±0.07	0.12±0.11	0.10±0.05	0.21±0.09	0.25±0.12	0.23±0.06
S-30	0.28±0.15	0.10±0.22	0.19±0.09	0.10±0.09	0.02±0.16	0.06±0.07
S-31	0.18±0.10	0.31±0.15	0.25±0.07	0.06±0.07	0.02±0.13	0.04±0.05
S-32	0.27±0.11	0.14±0.13	0.21±0.06	0.11±0.08	0.00±0.00	0.05±0.05

S-21- 23, S-25 not estimated

Table 14. Trend of heritability estimates for egg production up to 64 weeks (EP64) from different components over the generations

Gen.	IWN			IWP		
	Sire	Dam	Sire + Dam	Sire	Dam	Sire + Dam
S-19	0.07±0.03	0.06±0.05	0.07±0.03	0.06±0.04	0.08±0.06	0.07±0.03
S-20	0.13±0.05	0.25±0.07	0.19±0.04	0.18±0.06	0.11±0.06	0.14±0.04
S-24	0.15±0.05	0.42±0.07	0.28±0.04	0.21±0.06	0.14±0.06	0.18±0.04
S-25	0.08±0.04	0.16±0.08	0.12±0.04	0.03±0.06	0.27±0.08	0.14±0.04
S-26	0.15±0.06	0.03±0.07	0.09±0.03	0.01±0.03	0.29±0.08	0.15±0.04
S-27	0.03±0.04	0.27±0.08	0.15±0.04	0.07±0.04	0.18±0.07	0.13±0.03
S-28	0.01±0.04	0.38±0.12	0.19±0.06	0.096±0.07	0.13±0.12	0.11±0.05
S-29	0.03±0.05	0.09±0.11	0.06±0.06	0.06±0.06	0.27±0.12	0.16±0.05
S-30	0.01±0.13	0.32±0.27	0.16±0.11	0.07±0.10	0.01±0.01	0.04±0.07
S-31	0.08±0.07	0.20±0.15	0.14±0.06	0.01±0.06	0.04±0.13	0.03±0.05
S-32	0.03±0.06	0.41±0.14	0.22±0.06	0.13±0.08	0.00±0.00	0.06±0.05

S-21- 23 not estimated

Table 15. Trend of heritability estimates for 28 weeks egg weight (EW28)

Gen.	IWN			IWP		
	Sire	Dam	Sire + Dam	Sire	Dam	Sire + Dam
S-16	0.40±0.12	0.12±0.08	0.26±0.07	0.36±0.11	0.13±0.08	0.24±0.06
S-17	0.56±0.15	0.28±0.10	0.42±0.08	0.34±0.11	0.03±0.10	0.19±0.06
S-18	0.48±0.13	0.44±0.08	0.46±0.07	0.30±0.09	0.34±0.07	0.32±0.05
S-19	0.35±0.09	0.06±0.05	0.21±0.05	0.27±0.08	0.22±0.07	0.25±0.05
S-20	0.38±0.11	0.36±0.08	0.37±0.06	0.58±0.14	0.27±0.07	0.42±0.08
S-24	0.36±0.09	0.35±0.07	0.35±0.05	0.53±0.11	0.48±0.08	0.50±0.06
S-25	0.24±0.08	0.47±0.09	0.35±0.05	0.34±0.10	0.49±0.10	0.42±0.06
S-26	0.32±0.09	0.44±0.90	0.38±0.05	0.44±0.11	0.44±0.09	0.44±0.06
S-28	0.24±0.09	0.13±0.12	0.19±0.06	0.30±0.11	0.17±0.12	0.24±0.06
S-29	0.24±0.10	0.30±0.12	0.27±0.06	0.14±0.09	0.01±0.01	0.07±0.05
S-30	0.18±0.13	0.49±0.20	0.34±0.10	0.33±0.14	0.08±0.17	0.20±0.08
S-31	0.46±0.15	0.62±0.16	0.54±0.08	0.39±0.13	0.15±0.14	0.27±0.07
S-32	0.25±0.10	0.55±0.14	0.40±0.07	0.32±0.12	0.24±0.14	0.28±0.07

S-21- 23, S-27 not estimated

Table 16. Trend of heritability estimates for 40 weeks egg weight (EW40) from different components over the last 32 generations

Gen.	IWN			IWP		
	Sire	Dam	Sire + Dam	Sire	Dam	Sire + Dam
S-1	0.14±0.14	0.70±0.22	0.42±0.10	0.95±0.30	0.26±0.20	0.61±0.17
S-2	0.82±0.22	0.48±0.11	0.65±0.11	0.81±0.22	0.27±0.11	0.54±0.12
S-3	0.44±0.14	0.54±0.12	0.49±0.08	0.67±0.18	0.47±0.10	0.57±0.10
S-4	0.54±0.16	0.46±0.11	0.50±0.09	0.52±0.15	0.36±0.10	0.44±0.09
S-5	0.73±0.19	0.30±0.09	0.52±0.10	0.94±0.24	0.27±0.06	0.61±0.12
S-6	0.54±0.20	0.52±0.17	0.53±0.14	0.59±0.18	0.07±0.12	0.33±0.11
S-7	0.56±0.07	0.18±0.08	0.37±0.09	0.56±0.16	0.18±0.08	0.37±0.09
S-8	0.40±0.13	0.47±0.10	0.43±0.09	0.40±0.13	0.41±0.10	0.41±0.08
S-9	0.35±0.12	0.36±0.11	0.36±0.07	0.26±0.10	0.18±0.08	0.22±0.06
S-10	0.48±0.13	0.20±0.07	0.34±0.07	0.37±0.11	0.12±0.08	0.25±0.06
S-11	0.30±0.10	0.22±0.09	0.26±0.06	0.24±0.08	0.12±0.08	0.18±0.05
S-12	0.50±0.16	0.26±0.12	0.38±0.09	0.20±0.10	0.29±0.14	0.24±0.08
S-13	0.17±0.08	0.06±0.12	0.12±0.06	0.40±0.14	0.09±0.12	0.24±0.08
S-14	0.43±0.17	0.29±0.10	0.26±0.08	0.16±0.08	0.44±0.12	0.30±0.06
S-15	0.54±0.19	0.32±0.18	0.43±0.11	0.62±0.16	0.24±0.10	0.43±0.09
S-16	0.47±0.14	0.11±0.08	0.29±0.07	0.67±0.18	0.28±0.09	0.48±0.10
S-17	0.57±0.15	0.19±0.08	0.38±0.08	0.33±0.11	0.15±0.10	0.24±0.06
S-18	0.39±0.10	0.26±0.07	0.32±0.06	0.29±0.09	0.28±0.07	0.29±0.05
S-19	0.28±0.09	0.33±0.07	0.30±0.05	0.40±0.11	0.22±0.07	0.31±0.06
S-20	0.27±0.08	0.30±0.07	0.28±0.05	0.48±0.13	0.36±0.08	0.42±0.07
S-24	0.45±0.10	0.48±0.08	0.47±0.05	0.44±0.10	0.45±0.08	0.45±0.05
S-25	0.03±0.03	0.05±0.06	0.04±0.03	0.45±0.11	0.69±0.10	0.57±0.06
S-26	0.40±0.10	0.39±0.09	0.40±0.06	0.45±0.11	0.50±0.09	0.47±0.06
S-27	0.37±0.10	0.56±0.09	0.48±0.06	0.45±0.11	0.69±0.10	0.57±0.06

S-28	0.26±0.10	0.49±0.13	0.37±0.07	0.39±0.12	0.45±0.13	0.42±0.07
S-29	0.25±0.11	0.25±0.14	0.25±0.07	0.12±0.09	0.14±0.14	0.13±0.06
S-30	0.14±0.13	0.51±0.23	0.33±0.10	0.46±0.16	0.63±0.18	0.55±0.09
S-31	0.40±0.14	0.48±0.15	0.44±0.08	0.21±0.10	0.30±0.15	0.26±0.07
S-32	0.39±0.13	0.25±0.14	0.32±0.07	0.24±0.10	0.41±0.15	0.32±0.07

S-21- 23 not estimated

Genetic and phenotypic correlations

The genetic and phenotypic correlations of egg number (EP64) with ASM were mostly negative and high in magnitude in different generations in both IWN and IWP strains. These correlations were measured in selected generations. The genetic and phenotypic correlations between ASM and EP40 were estimated for all 20 generations and most of the estimates were found to be negative in different generations. The genetic correlation between ASM and EW40 were mostly positive and observed to be reduced over generations in both the strains. The phenotypic correlations were also mostly positive but low in magnitude in both the populations in different generations.

The estimates of genetic and phenotypic correlations between EP40 and EW40 for both the strains were mostly negative in different generations. The estimates of genetic and phenotypic correlation between EP40 and EW28 for both the strains (IWN and IWP) were found to be mostly negative. The r_g and r_p values between EP64 and EW28 were negative in direction. The genetic and phenotypic correlations between EP64 and EW40 were mostly negative in different generations for both the strains.

Negative genetic and phenotypic correlations between ASM and BW20 were observed over the generations (from S-1 to S-17) for both the strains. The genetic and phenotypic correlations between ASM and BW16 were negative over the generations in both IWN and IWP strains. The genetic and phenotypic correlations between BW16, BW20 and BW40 were found to be positive and very high in different generations which indicated the same combinations of genes influence both the traits in same direction.

The genetic and phenotypic correlations between body weight (BW16, BW20, BW40) with egg weight (EW 40 and EW64) were all positive for both the strains in different generations, all heavier birds laid large sized eggs. The correlation between body weights (BW20, BW40) and egg production (EP40 and EP64) were mostly negative in direction. Although low magnitude positive phenotypic correlation coefficients were observed between the traits in some generations, the genetic correlation estimates were mostly negative over the generations.

Response to selection

The phenotypic and genetic response over the last five generations for important economic traits was presented in Tables 17 and 18, respectively. The phenotypic response to EP64 (survivors') was 15.01 and 19.80 eggs in IWN and IWP lines in the present generation (S-32), However, the genetic response was in negative direction (Table 18). Prolonged selection for the trait over the last 15 generations might be the possible reason for the reduction in the response. All other traits also showed similar trend with fluctuations in different generations. The trend of phenotypic and genetic response shown in Figure 2 and 3.

Table 17. Phenotypic response in primary and various correlated traits in last five generations

Traits	S-28		S-29		S-30		S-31		S-32	
	IWN	IWP	IWN	IWP	IWN	IWP	IWN	IWP	IWN	IWP
ASM, d	5.45	0.52	-3.1	0.24	-1.78	-4.45	4.79	4.10	-12.55	-8.80
Body weight, g										
16 wks	-81.48	-78.49	14.14	-12.17	30.11	61.00	-33.0	-20.99	219.2	186.2
40 wks	114.9	45.27	-113.7	-103.8	50.21	14.18	-65.50	-104.0	19.65	52.75
64 wks	-99.3	-145.85	-45.84	-98.9	3.64	57.56	-0.20	-46.43	84.65	162.59

Traits	S-28		S-29		S-30		S-31		S-32	
	IWN	IWP	IWN	IWP	IWN	IWP	IWN	IWP	IWN	IWP
Egg weight, g										
28 wks	-0.98	-1.52	-0.67	0.17	0.78	0.23	2.18	1.43	-1.46	-0.18
40 wks	0.25	-0.63	-0.01	0.67	-0.12	-0.02	-1.04	-1.67	-0.13	0.41
64 wks	0.07	-1.33	-0.97	-1.72	-0.63	0.22	-0.67	-.0.07	2.18	3.36
EP40, Nos.										
Hen Housed	-5.61	-1.28	0.31	-2.31	-2.51	3.80	0.93	-0.40	-0.40	-0.95
Hen Day	-5.38	-1.56	-0.61	-1.03	-.0.28	3.71	-0.77	-4.80	4.02	2.44
Survi-vors'	-5.25	-0.43	-1.03	-2.12	1.24	5.18	-1.90	-5.42	5.90	4.01
EP64, Nos.										
Hen Housed	-8.12	6.26	-1.73	-0.10	-9.31	-13.47	17.45	-0.11	-5.63	-0.57
Hen Day	-9.66	4.49	-0.99	1.20	3.02	-4.96	4.61	-10.70	10.75	15.36
Survi-vors'	-8.28	5.79	-2.19	0.57	7.27	-0.97	-0.14	-8.58	15.01	19.80

Table 18. Genetic response (gain) in primary and various correlated traits in last five generations

Traits	S-28		S-29		S-30		S-31		S-32	
	IWN	IWP	IWN	IWP	IWN	IWP	IWN	IWP	IWN	IWP
ASM, d	-2.33	-7.26	-4.60	-1.26	-3.42	-6.09	13.59	12.90	-8.77	-3.81
Body weight, g										
16 wks	-102.6	-99.61	-6.70	-33.01	41.81	72.70	19.90	31.91	112.9	79.93
40 wks	363.3	293.6	160.6	170.6	-86.83	-122.8	48.86	10.32	-63.81	-30.06
64 wks	-99.30	-145.9	-49.81	-2.87	-34.24	19.68	26.18	-20.45	-80.97	-2.92
Egg weight, g										
28 wks	-2.49	-3.03	3.04	3.88	-3.87	-4.42	4.59	3.84	-3.98	-0.1
40 wks	0.65	-0.23	1.19	1.87	-2.12	-2.02	1.19	0.56	0.55	1.09
64 wks	-0.03	-0.39	-3.78	-4.53	-2.99	-2.14	0.02	0.62	-2.02	-0.84
EP40, Nos.										
Hen Housed	9.18	13.51	0.22	-2.40	-3.51	2.80	-6.95	-8.32	-5.52	-5.79
Hen Day	8.24	12.06	3.63	3.21	-0.17	3.82	-7.58	-11.63	-3.72	-5.08
Survivors'	7.66	13.48	1.7	0.61	-0.09	3.85	-9.17	-12.72	1.35	-0.57
EP64, Nos.										
Hen Housed	32.89	47.20	1.81	3.44	-12.07	-16.23	19.78	2.22	-33.84	-28.16
Hen Day	16.90	31.0	6.17	8.36	2.49	-5.49	9.37	-5.94	-21.78	-17.44
Survivors'	16.31	30.38	3.90	6.66	9.19	0.95	1.39	-7.05	-18.69	-14.07

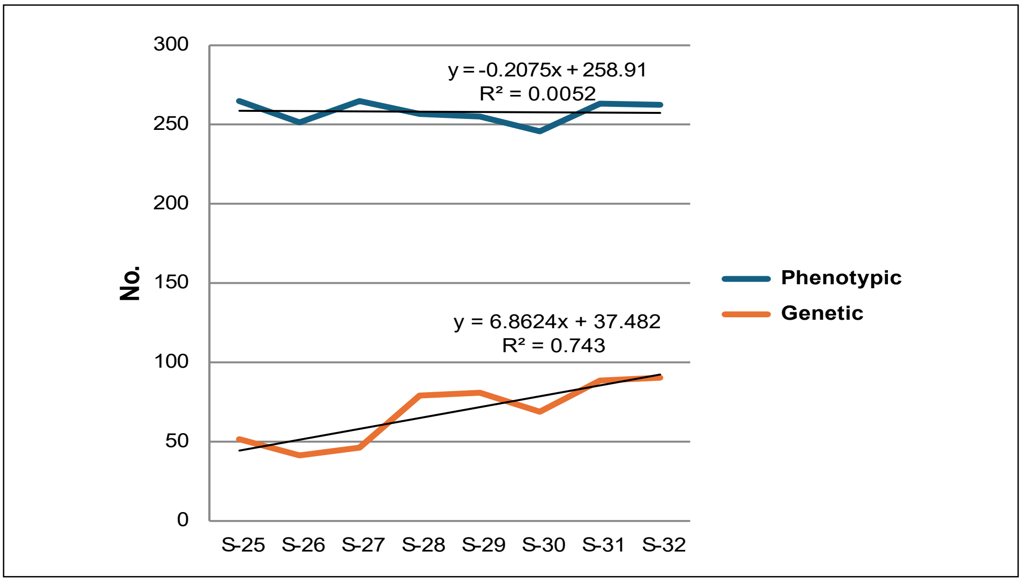


Figure 2: Trend of phenotypic and genetic response for EP64 in IWN line

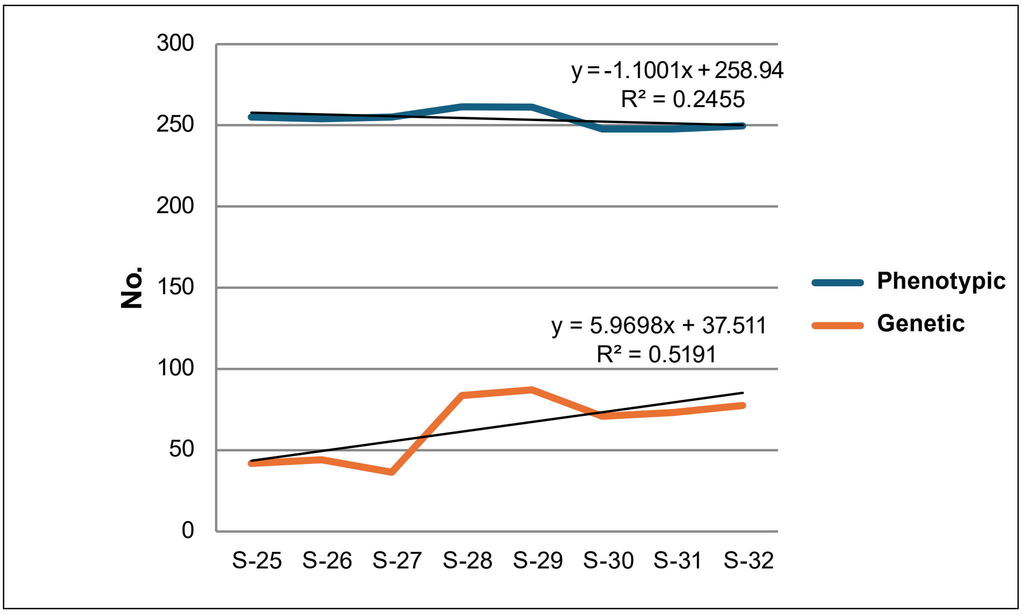


Figure 3: Trend of phenotypic and genetic response for EP64 in IWP line

Random sample test results

The Random Sample Test (RST) results have been presented in Tables 19 and 20. The 14th RST, which was held on Bhubaneshwar in 1990-1991 evaluated ILM90 as the best performer as compared to other strain crosses in the same RST. Hen house and hen day egg production, egg weight, FCR and margin of profit over food cost were best for ILM90 (or NP strain cross) during 14th RST. However, thereafter the performance of this strain cross was little lower as compared to some other crosses.

DPR, Hyderabad test results

The strain cross of Mannuthy centre has showed constant performance over the years from 1991-1992 to 1994-95 (Table 20).

Table 19. Random sample test results

Entry code	Strain code	Egg production		Average Egg Wt.	Feed consumption	Feed/ dozen eggs	Margin of profit over feed cost
		H.H	H.D.				
RST unit. Bangalore (1986-87)							
	NP	266.8	268.7	54.15	115	1.75	+42.36
RST unit, Bhubaneswar – 14th RST (1990-91)							
A	ILM-90	275.3	280.5	50.17	101	1.69	+63.20
I	BV300	265.5	281.5	51.93	102	1.71	+59.61
D	WLH S/C CPBF, HESS.	251.4	255.1	46.82	97	1.79	+37.46
J	STARCROSS	248.2	251.1	52.62	98	1.83	+44.80
H	K.B. CPBF, BHUB	248.1	274.4	50.05	108	1.85	+40.27
RST unit, Bangalore– 22nd RST (1990-91)							
B	ILM-90	245.8	267.5	54.7	113	1.91	+41.88
15	CARI S/C	256.5	270.2	52.9	112	1.88	51.56
1	BV 300	242.2	256.6	55.7	113	1.99	+42.89
4	HH 260	246.1	257.2	53.2	112	1.97	+44.13
RST unit, Bangalore– 23rd RST (1990-91)							
4	ILM-90	261.0	279.7	52.8	121	1.90	+32.25
3	BV 200	267.9	278.5	54.1	118	1.87	+32.58
6	HH 260	241.5	258.0	50.6	121	2.06	+11.4
7	STRAIN CROSS	238.4	250.7	53.8	120	2.09	+09.43
8	STAR CROSS	236.6	245.2	54.3	118	2.12	+12.14
RST unit, Bangalore – 26th RST (1995-96: 01-04-1995 To 17-08-1996)							
A) (Deep Litter)							
AICRP(P) Mannuthy		215.8	233.9	54.9	124	2.34	(-)37.73
HAU, Hisar		220.8	235.9	53.59	126	2.36	(-)40.03
CARI. Izatnagar (UP)		238.7	253.2	55.06	126	2.21	(-)26.06
CPBF, Hesarghatta		215.9	229.4	53.13	120	2.31	(-)40.59
Deejay		221.8	236.8	55.29	126	2.35	(-)40.05
Deejay Dekalb		239.0	253.1	57.86	126	2.20	(-)22.65

Entry code	Strain code	Egg production		Average Egg Wt.	Feed consump-tion	Feed/ dozen eggs	Margin of profit over feed cost
		H.H	H.D.				
RST unit, Bangalore– 26th RST (1995-96: 01-04-1995 To 17-08-1996)							
B) (Cages)							
AICRP(P) Mannuthy		211.5	227.0	54.61	121	2.36	(-)47.94
HAU, Hisar		199.2	215.0	54.22	121	2.50	(-)56.20
CARI. Izatnagar (UP)		217.7	234.6	54.83	122	2.31	(-)46.51
CPBF, Hasarghatta		216.3	228	53.46	120	2.32	(-)48.98
Deejay Dekalb		212.1	226.7	56.62	120	2.35	(-)46.27
RST unit, Bhubaneswar-19th RST (1995-96: 10-03-1995 To 17-08-1996)							
AICRP(P) Mannuthy		228.4	236.0	54.49	112	2.49	(-)20.49
Dept. of A.G. & BCARI, Izatnagar (UP)		253.1	259.8	53.10	112	2.20	(+)6.71
CPBF, Hesarghatta		203.3	211.6	61.60	116	2.84	(-)62.39
M/S Venkateswara Hatcheries Pune		248.4	273.9	57.20	119	2.30	(-)0.46
M/s Bovn's poultry breeders (P) Ltd. Secunderabad		205.7	238.2	56.30	110	2.40	(-)17.47
RST unit, Bangalore -31st RST (2000-2001)							
a) Cage House							
1. HH 260		297.0	302.3	56.61	117	1.78	+63.53
2. RW		271.5	282.9	56.55	119	1.95	+40.37
3. Strain cross		249.7	255.2	54.79	117	2.11	+11.03
4. DKXL –I		249.7	254.3	56.97	117	2.11	+18.94
5. BV 300		292.4	293.9	58.19	115	1.81	+54.70
6. ILR - 90 Jubilee		237.5	239.8	60.85	116	2.23	+4.78
7. H & N Layer		272.1	274.2	54.39	116	1.94	+44.41
8. Strain cross		245.8	253.8	55.92	118	2.15	+4.20
9. ILM - 90		271.3	282.1	58.23	119	1.94	+40.14
10. Straincross - I		298.4	301.8	57.41	116	1.77	+58.29
RST unit, Banglore -32st RST (2001-2002)							
a) Cage House							
1. ILM - 90		266.1	287.7	57.05	121	1.96	+5.01
2. RW CPBF, Mumbai		191.7	198.3	61.00	120	2.79	-88.13
3. M/s Pioneer Hatcheries		272.96	287.7	57.88	119	1.91	+13.91
4. ILR-90 Jubilee		266.8	277.6	57.11	118	1.96	+7.16
5. HH 260 CPBF		256.7	277.9	56.38	123	2.04	-10.96
6. BV 300 (Venkateswara-I)		294.2	303.2	57.07	117	1.77	+36.54
7. BV 300 (Venkateswara-II)		282.3	290.3	59.11	116	1.85	+25.78

Entry code	Strain code	Egg production		Egg Wt.	Feed consumption	Feed/ dozen eggs	Margin of profit over feed cost
		H.H	H.D.				
RST unit, Bangalore -31st RST (2000-2001)							
b) Deep Litter							
1. HH 260		250.64	276.7	55.53	140	2.33	-31.26
2. RW		209.6	235.6	58.31	144	2.83	-74.04
3. Strain cross		243.1	250.8	54.30	128	2.36	-26.41
4. DKXL - I		254.0	268.1	57.47	134	2.31	-13.08
5. BV 300		281.6	287.9	56.46	131	2.10	+8.07
6. ILR - 90 Jubilee		246.7	253.7	55.17	131	2.38	-25.76
7. H & N Layer		258.7	267.3	57.22	133	2.29	-11.42
8. Strain cross		264.8	267.9	55.24	130	2.24	-5.64
9. ILM - 90		269.0	269.8	55.76	129	2.20	-0.14
10. Strain cross – I		281.5	289.1	54.17	133	2.12	+3.24
RST unit, Bangalore - 32st RST (2001-2002)							
b) Deep Litter							
1. ILM - 90		279.3	288.1	57.00	132	2.12	-19.03
2. M/S Pioneer Hatcheries		280.7	285.3	58.40	134	2.17	-29.76
3. ILR-90 Jubilee		272.6	278.8	55.57	129	2.14	-26.02
4. HH 260 CPBF		256.2	268.4	56.27	130	2.24	-44.42
5. RW CPBF, Mumbai		170.6	194.3	59.50	143	3.40	-155.42
6. BV 300 (Venkateswara-I)		290.1	295.6	55.84	130	2.03	-7.79
7. BV 300 (Venkateswara-II)		278.4	290.2	57.43	133	2.12	-20.78

Table 20. ICAR-DPR, Hyderabad Test Results

Name of the centre/ Entry	ASM (days)	32. wk EW (g)	40. wk EW (g)	20. wk BW (g)	40. wk BW (g)	EP (HH No.)	
						40 wks	72 wks
1. 1991-92 – 1st Test							
Mannuthy	153	54.62	55.75	1257	1769	118	270
Anand	163	55.89	58.24	1074	1608	100	214
CARI	149	51.30	52.68	1250	1685	115	230
Hyderabad	147	54.43	56.25	1291	1759	110	228
PDP (ICAR-DPR)	159	50.16	51.81	1164	1727	103	225

Name of the centre/ Entry	ASM (days)	32. wk EW (g)	40. wk EW (g)	20. wk BW (g)	40. wk BW (g)	EP (HH No.)	
						40 wks	72 wks
2. 1992-93 – 2nd test							
Mannuthy	152	54.84	56.32	1257	1774	118	270
Anand	161	56.14	58.29	1105	1606	69	214
CARI	148	51.95	52.81	1244	1686	110	230
Hyderabad	146	54.42	56.29	1286	1760	100	206
PDP (ICAR-DPR)	159	50.21	51.86	1170	1722	98	212
3. 1993-94 3rd Test							
Mannuthy	149	20.72	52.75	1345	1498	102	110
Anand	132	51.98	53.39	1240	1499	105	109
CARI	144	51.85	52.81	1351	1369	117	118
Hyderabad	145	53.59	55.75	1339	1440	104	113
PDP (ICAR-DPR)	152	48.21	49.81	1245	1498	104	109
4. 1994-95 – 4th Test							
Mannuthy	149.5	53.60	51.50	1313	1634	112.0	121.3
CARI, Izatnagar	140.7	53.60	51.50	1254	1503	110.9	112.1
Hyderabad	148.4	54.50	53.70	1205	1523	102.6	105.0
Commercial 1	152.9	55.30	53.50	1121	1344	116.0	117.
Commercial 2	152.8	58.30	55.00	1203	1461	116.0	116.0
Commercial 3	154.4	55.40	53.60	1084	1398	106.2	109.3
Commercial 4	156.4	59.70	57.40	1190	1554	110.1	110.4

2 Anand Agricultural University, Anand

During the Vth five-year plan, a sub-centre of AICRP on poultry breeding was established. The center was entrusted with testing of various genotypes evolved at various centres of ICAR in the country with noted commercial stocks. It was, thereafter upgraded to full-fledged centre during VII five-year plan. Later on, the centre was assigned alternative poultry breeding programme on RRS involving IWD and IWK lines from Hyderabad centre and remarkable improvement was made in the productivity of these lines. This centre, later on, procured IWN and IWP from Mannuthy centre in the year 1994. Since 1994, this centre is engaged in the improvement of IWN and IWP lines.

Achievements

The centre has evaluated IWN and IWP strains for 14 generations and 2 generations of selection for germplasm acquired from Mannuthy centre has also been completed.

Selection records

In the last five generations of selection, 50 sires and around 250 females have contributed with effective population size being more than 163 for IWN and more than 165 for IWP lines. The selection intensity was highest in S-0 to S-1 generations for both the lines since it was the first generation of introduction of Mannuthy germplasm. Selection differential for egg production was highest in S-12 to S-13 and S-0 to S-1 generations for IWN and IWP respectively. The detailed summary of selection records for IWN and IWP strains raised at Anand centre has been shown in Table 21.

Table 21. Summary of selection records of IWN and IWP strains for last five generations at Anand centre

Strains	Gens.	Sires	Dams	Ne (Contributed)	SD in females	SI (σ)
IWN	S-12	50	262	168	11.40	0.41
	S-13	50	249	166.6	15.70	0.486
	S-14	50	301	171.5	-	0.28
	S-1	50	226	163.77	10.56	0.66
	S-2	50	263	168.05	5.30	0.212
IWP	S-12	50	271	169	3.98	0.13
	S-13	50	241	165.6	15.70	0.406
	S-14	50	302	171.59	-	0.23
	S-1	50	247	166.33	17.94	0.623
	S-2	50	251	166.78	5.62	0.215

Incubation records

In the last five generations, the highest fertility and hatchability percentage for IWN and IWP lines was reported for S-0 generation, though it declined thereafter. S-3 generation in IWN line witnessed 83.78% fertility with total eggs and fertile eggs hatchability of 71.30% and 85.11% respectively. On the other hand, in S-3 generation, IWP line showed 74.50% fertility with total eggs and fertile eggs hatchability of 62.60% and 84.04% respectively. The incubation records for IWN and IWP lines have been presented in Table 22.

Table 22. Incubation records of IWN and IWP over the generations at Anand centre

Gen.	IWN				IWP			
	No. of eggs set	Fertility (%)	Hatchability (%)		No. of eggs set	Fertility (%)	Hatchability (%)	
			TES	FES			TES	FES
S-4	4939	89.98	72.46	80.54	2690	91.26	73.01	80.00
S-5	8237	92.92	70.66	76.04	4273	93.73	81.44	86.89
S-6	8771	90.63	56.9	62.79	6496	90.92	68.77	75.64
S-7	8284	89.88	68.61	76.34	7092	90.27	72.12	79.98
S-8	7884	92.77	74.35	80.15	6766	90.13	72.89	80.88
S-9	8316	84.85	58.26	68.66	7500	86.53	66.63	76.99
S-10	6977	84.17	61.01	72.48	6370	84.84	67.11	79.10
S-11	6451	90.11	69.43	77.05	6241	89.71	70.74	78.85
S-12	4018	72.48	51.20	70.63	3817	71.63	56.56	78.96
S-13	3325	90.16	66.34	73.58	3192	92.24	76.91	83.38
S-14	4685	75.55	54.81	59.25	4312	77.75	72.62	76.91
Germplasm received from Mannuthy								
S-0	2181	94.96	85.92	90.49	2207	92.48	85.23	92.16
S-1	1258	88.31	74.64	84.52	1455	86.12	73.20	85.00
S-2	1432	85.68	76.54	89.32	1385	84.26	70.83	84.06
S-3	1603	83.78	71.30	85.11	1337	74.50	62.60	84.04

Mortality over the generations

Mortality recorded at 0-8, 9-20, 9-16, 17-40, 21-40, 17-64 and 21-64 weeks of age starting from S_2 generation in IWN and IWP lines maintained at Anand centre have been summarized in Table 23. From S_7 generation onwards, mortality was only recorded at 0-8, 9-16, 17-40 and 17-64 weeks of age.

Table 23. Mortality (%) over the generations in both the strains at Anand centre

Strain	Gen.	Age (wks)						
		0-8	9-20	9-16	17-40	21-40	17-64	21-64
IWN	S-2	12.17	3.63	-	-	1.64		6.02
	S-3	8.45	4.59	-	-	4.38		8.13
	S-4	6.15	2.51	-	-	2.04	--	-
	S-5	6.04	-	1.23	7.59	-	11.56	-
	S-6	4.04	-	1.70	14.09	-	20.73	-
	S-7	12.99	1.61	-	-	1.96	-	-
	S-8	5.24	-	1.39	5.33	-	10.39	-
	S-9	6.38	-	1.85	5.72	-	13.02	-
	S-10	6.23		1.17	3.00		6.29	
	S-11	2.51		2.73	7.23		13.34	
	S-12	4.21		2.67	3.12		11.98	
	S-13	4.56		0.83	7.15		9.65	
	S-0 (Mannuthy)	4.23		2.38	3.41		4.23	
	S-1	2.96		4.35	2.69		5.38	
	S-2	4.15		10.30	4.01		7.75	

Strain	Gen.	Age (wks)						
		0-8	9-20	9-16	17-40	21-40	17-64	21-64
IWP	S-2	10.86	6.37	-	-	3.43		6.62
	S-3	8.63	3.48	-	-	3.82		7.76
	S-4	7.03	3.51	-	-	1.45	15.55	-
	S-5	4.13	-	0.49	4.35	-	8.27	-
	S-6	5.57	-	2.89	10.57	-	16.51	-
	S-7	12.96	2.70	-	-	1.82	-	-
	S-8	9.35	-	1.48	12.42	-	17.23	-
	S-9	9.99	-	1.64	9.72	-	17.75	-
	S-10	5.10		1.05	3.09		7.78	
	S-11	2.80		4.14	19.18		28.11	
	S-12	4.74		3.57	3.44		14.98	
	S-13	5.04		1.71	8.01		10.18	
	S-0 (Mannuthy)	3.02		1.13	2.10		2.74	
	S-1	4.83		0.56	1.99		3.42	
	S-2	7.31		1.91	4.51		13.52	

Performance of the traits

Body weight and age at sexual maturity

Body weight at 40 weeks and 72 weeks increased significantly in both the lines from S-1 to S-2, however, age at sexual maturity also unfavourably registered an increase in the aforementioned generations in IWN and IWP (Table 24). In control population, body weight at 40 weeks increased whereas ASM declined under the natural forces of selection.

Egg production

Since the introduction of germplasm from Mannuthy centre, EP64 and EP72 has witnessed a significant increase in both the lines. In IWN line, EP64 improved from 211.05 to 263.60 from S-14 to S-0 generations whereas in IWP line, EP64 increased from 197.87 to 250.50 during the same period. Since then, the egg production at 64 weeks has been maintained at more than 250 eggs in both the lines (Table 25). The trend of phenotypic and genetic response for the two lines for EP64 has been diagrammatically shown in the Figures 4 and 5.

Table 24. Mean body weights (g) at various ages and age at sexual maturity (days) over the generations in different strains

Gen.	IWN			IWP			Control		
	BW40	BW72	ASM	BW40	BW72	ASM	BW40	BW72	ASM
S-2	1483.2	-	145.3	1569.3	-	146.4	1456.8	-	146
S-3	1218.2	1651.2	148.6	1278.3	-	146.1	1544.6	-	153
S-4	1522.2	1559.7	149.5	1576.6	1666.3	147.5	1489.9	1361	151
S-5	1579.9	1641.6	140.8	1695.6	1705.5	144.4	1598.3	1667.8	139
S-6	1442.8	1635.2	150.8	1462.5	1687.9	150.1	1505.9	1553.3	158.4

Gen.	IWN			IWP			Control		
	BW40	BW72	ASM	BW40	BW72	ASM	BW40	BW72	ASM
S-7	1524.8		141	1604.8		144.2	1487.6		147.4
S-8	1502.7		151	1547.6		155.4	1482.8		160.1
S-9			144.5			151			150.42
S-10	1457	1524	137.09	1505	1616	139.13	1484	-	155.46
S-11	1656	1755	145.26	1689	1775	144.91	1551	-	151.07
S-12	1629	1682	138.3	1645	1881	141.9	1640	-	144.7
S-13	1608	1825	148.6	1587	1810	150.9	1501	-	157.2
S-14	1566		145.4	1624		148.3	-		148.5
S-0	1468	1678	143.66	1555	1700	140.55	1460	-	148.85
S-1	1540	1674	133.9	1581	1685	131	1652	-	145.7
S-2	1656	1744	138.7	1636	1779	133.2	1660	-	140.7

Table 25. Egg production (Nos) to 40 (EP40), 64 (EP64) and 72 (EP72) weeks of age over last five generations in different strains

Gen.	IWN			IWP			Control		
	EP40	EP64	EP72	EP40	EP64	EP72	EP40	EP64	EP72
S-2	117	247.6	310.4	113.5	233.8	297.8	105.7	220.7	--
S-3	108.4	243.1	287.7	107.9	232.4	275.9	86.73	192.6	--
S-4	118.1	255	294.5	114.1	240.2	277.3	104.7	212.7	245.3
S-5	126	267.8	309.6	119.6	258.8	294.3	115.2	240.4	273.9
S-6	116.7	254.6	298.7	114.7	244.3	282.2	88.8	181.02	213.5
S-7	118.6	248.2		112.3	234.2		106.4	223	
S-8	109.5	241		101	241.5		88.1	203	
S-9	118.8	244.7	284.93	112.6	229.7	270.41	97.1	193.3	223.47
S-10	118.73	249.96	288.34	115.53	243.55	277.17	89.63	197.04	-
S-11	112.54	232.23	301.84	98.93	199.74	300.32	103.4	218.6	-
S-12	127.4	253.1	294.2	121.2	243.6	274.96	104.0	206.1	-
S-13	98.25	211.05	233.48	93.24	197.87	219.46	76.95	169.45	-
S-14	120.66	211.05	233.5	110.41	197.87	219.5	-	169.45	-
S-0	120.4	263.6	298.8	119.3	250.5	284.7	100.3	213.9	-
S-1	127.2	256.5	294.3	129.4	260.7	299.6	106.1	193.2	-
S-2	126.77	264.06	303.37	124.95	261.59	301.73	108.59	222.53	-

Egg weight

Since the introduction of Mannuthy germplasm, the overall trend in egg weights at 40 and 72 weeks was a declining one with EW40 and EW72 in both the lines hovering around 52 gm and 54 gm respectively (Table 26).

Table 26. Mean egg weights (g) at various ages over the generations in different strains

Gen.	IWN		IWP		Control	
	EW40	EW72	EW40	EW72	EW40	EW72
S-2	49.8	-	50.5	-	51.1	-
S-3	42.9	-	44.1	55	50.1	-
S-4	51.6	53.5	51.4	54.8	53.4	52.8
S-5	50.4	53.4	51.1	55.2	52.5	56.8
S-6	50.3	55.1	50.6	57.01	49.9	56.4
S-7	50.03		51.4		50.7	
S-8	50.44		51.11		51.27	
S-9	50.30		51.50		50.68	
S-10	51.30	52.03	52.64	54.58	51.92	-
S-11	52.21	54.20	53.10	54.87	51.53	
S-12	53.57	54.66	54.49	55.61	54.79	-
S-13	52.10	54.09	52.73	55.63	51.66	-
S-14	52.09		54.06	-	-	
S-0	52.33	55.09	53.31	55.20	51.62	-
S-1	52.05	55.17	52.69	55.16	52.34	-
S-2	52.62	54.04	52.87	54.34	52.93	-

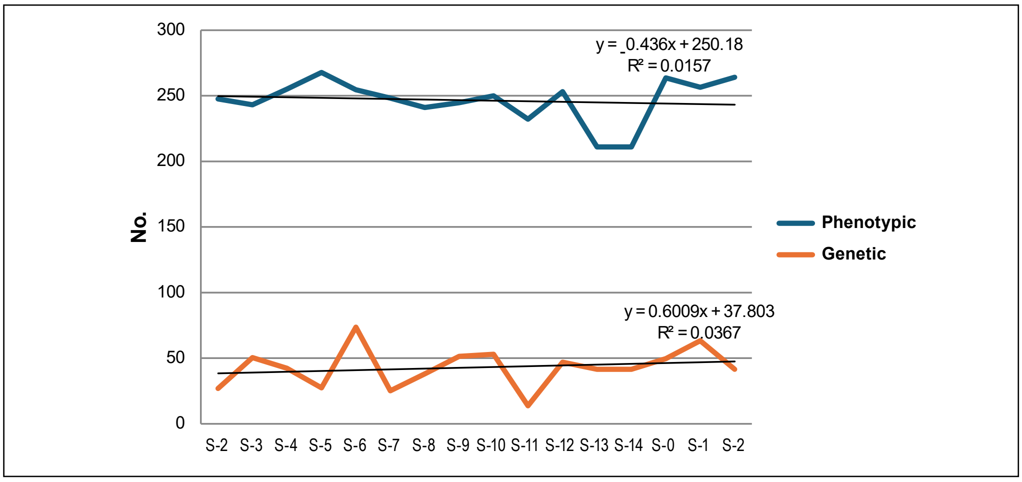


Figure 3: Trend of phenotypic and genetic response for EP64 over the generations in IWN line (Anand centre)

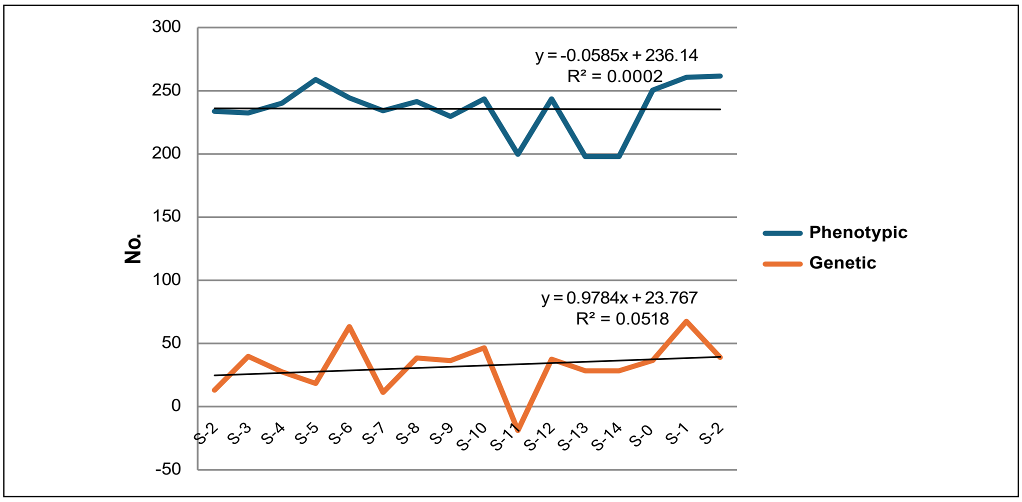


Figure 4: Trend of phenotypic and genetic response for EP64 over the generations in IWP line (Anand centre)

Table 27. Trend of heritability estimates for age at sexual maturity and body weight traits over the generations at Anand centre

Strain	Gen.	ASM	BW16	BW40	BW64
IWN	S-10	0.460±0.104	-	0.193±0.060	0.124±0.048
	S-12	-	0.135±0.068	0.069±0.057	0.074±0.061
	S-13	0.162±0.116	0.026±0.095	0.038±0.097	-
	S-2	0.073±0.134	0.169±0.147	0.115±0.145	0.261±0.170
IIWP	S-10	0.174±0.057	-	0.404±0.094	0.328±0.082
	S-12	0.090±0.061	0.081±0.059	0.027±0.050	0.080±0.070
	S-13	0.034±0.102	-	-	0.224±0.131
	S-2	0.352±0.199	0.424±0.206	0.049±0.169	0.508±0.232

Genetic parameters

The heritability estimates of ASM, BW16, BW40 and BW64 reported an increase in the last generation of selection. The estimates for body weight traits over the generations are presented in Tables 27. Egg quality traits were estimated in S-11 generation and it was revealed that yolk index and shell thickness were high heritability traits whereas meat spot and blood spot percentage reported zero heritability. The heritability estimates for albumen index, yolk index and shell thickness was 0.12±0.004, 0.38±0.004 and 0.31±0.003 in IWN and 0.11±0.003, 0.36±0.003 and 0.31±0.003 in IWP respectively.

Heritability for egg production traits like EP40 and EP64; egg weight traits like EW40 and EW64 in IWN line unexpectedly showed a decreasing trend even after introduction of genetic variability in S-0. However, the precision of these estimates is less since the standard error values are very high. On the contrary, all the traits, particularly, EP40 and EP64 showed an increase in the heritability estimates in IWP line. Again, standard errors of heritability estimates are higher in IWP line as well (Table 28).

Table 28. Trend of heritability estimates for egg weight and egg production traits over the generations at Anand centre

Strain	Gen.	EP40	EP64	EW28	EW40	EW64
IWN	S-9	-	0.055±0.034	0.326±0.079	-	-
	S-10	0.379±0.091	0.167±0.055	0.189±0.060	0.132±0.050	0.022±0.028
	S-12	0.025±0.049	0.064±0.064	0.073±0.057	-	-
	S-13	0.191±0.121	0.192±0.121	0.152±0.122	-	-
	S-2	0.130±0.148	0.030±0.134	0.056±0.136	0.060±0.137	0.095±0.163
IWP	S-9	-	0.196±0.062	0.095±0.042	-	-
	S-10	0.190±0.059	0.144±0.051	0.092±0.043	0.036±0.032	0.007±0.027
	S-12	0.082±0.059	0.017±0.050	0.072±0.05	0.053±0.054	0.079±0.070
	S-13	0.124±0.116	0.241±0.132	0.156±0.132	-	-
	S-2	0.164±0.182	0.353±0.204	0.085±0.165	0.068±0.174	0.215±0.215

Response to selection

The phenotypic and genetic response for EP64 was -2.82 and 0.43 in IWN and -2.48 and 0.78 in IWP respectively over the 10 generations (S-4 to S-13). The average phenotypic response for EP64 trait was negative while the genetic response was positive in both the lines.

3 Acharya N.G. Ranga Agricultural University, Hyderabad

ANGRAU, Hyderabad, formerly known as Andhra Pradesh Agricultural University (APAU) and presently known as Sri Venkateswara Veterinary University (SVVU) was one of the major centres of AICRP for egg. The basic germplasm made available to ANGRAU, Hyderabad centre in 1971-72 constituted six indigenous and four exotic strains of WLH. After initial evaluation, two indigenous strains were discarded and breeding programme was continued with four indigenous and four exotic strains. After few cycles of selection, IWA, IWE and IWO were discontinued and two exotic strains IWN and IWP were sent to the AICRP on Poultry, Mannuthy. IWH, IWI and IWK were transferred to ICAR-DPR, Hyderabad. Hyderabad centre was assigned to work on IWD and IWF strains. The centre was discontinued from 2015.

Achievements

Intra-population selection was practiced in these two populations following Osborne index method for egg production to 64 weeks of age with independent culling level selection for egg weight at 28 weeks of age.

Selection records

IWD and IWF populations underwent 30 and 29 generations of selection respectively. 50 sires and 293 dams of IWD line in S-30 generation and 50 sires and 287 dams of IWF line in S-29 generation contributed to the progeny. Selection intensity was 0.6 in both the lines in last generation of selection (Table 29).

Table 29. Summary of selection records of IWD AND IWF over last few generations

Strains	Gens.	Sires	Dams	SD in females	SI (σ)
IWD	S-20	50	291	31.16	0.65
	S-21	50	281	30.10	0.55
	S-22	50	300	22.2	0.53
	S-23	50	297	27.25	0.83
	S-24	50	232	31.0	0.89
	S-25	50	285	27.2	0.74
	S-26	50	295	26.3	0.76
	S-27	50	295	26.30	0.76
	S-28	50	287	30.34	0.69
	S-29	50	299		0.60
	S-30	50	293		0.68
IWF	S-20	50	265	28.90	0.45
	S-21	50	300	26.3	0.62
	S-22	50	295	25.32	0.81
	S-23	50	269	28.1	0.77
	S-24	50	286	24.95	0.70
	S-25	50	292	25.45	0.72
	S-26	50	292	25.45	0.72
	S-27	50	274	24.06	0.46
	S-28	50	299		0.55
	S-29	50	287		0.60

Incubation records over the generations

Fertility and hatchability data presented in Table 30 shows that since the start of these populations, fertility has improved from 67.5% to 86.5% in IWD line whereas IWF line has witnessed an increase from 65.4% to 83.5%. Similarly, TES and FES from first to last generation increased from 55.4% and 55.1% to 77.2% and 89.2% respectively in IWD line while the corresponding increases in TES and FES in IWF line was 49.2% and 62.5% to 73.2% and 87.7% respectively.

Table 30. Fertility and hatchability performance of two strains over the generations

Gen.	IWD			IWF		
		Hatchability (%)			Hatchability (%)	
	Fertility (%)	TES	FES	Fertility (%)	TES	FES
S-0	67.5	-	55.1	65.4	-	62.5
S-1	57.7	-	58.9	52.8	49.2	52
S-2	87.8	55.4	87.2	80	57.1	79.1
S-3	94.9	88.4	93.1	92.1	83.5	90.9
S-4	93.9	89.5	95.4	92.5	84.6	91.4
S-5	90.3	84.6	93.7	86	77.8	90.5
S-6	92.2	79.9	86.7	90.9	75.6	83.1
S-7	83.4	75.4	90.4	75.8	67.8	89.3
S-8	79.7	71.9	90.2	79.6	68.1	85.6
S-9	79.4	71.4	91.1	83.9	76.1	90.8
S-10	80.2	72.9	86.5	88.2	79.6	90.2
S-11	79.5	71.6	90.1	91.5	85.1	92.8
S-12	85.8	79.4	92.6	92.1	81.6	88.6
S-13	83.4	74	88.6	88.9	75.4	83.3
S-14	84.5	72.1	85.2	91.3	81.1	88.7
S-15	90.8	79.5	87.5	82.1	64	77.9
S-16	81.3	64.6	79.4	81.9	63.5	76.1
S-17	80.4	63.4	78.4	74	44	59
S-18	80	54	68	79.9	48.8	57.4
S-19	84.4	53.4	63.3	82.9	57.1	69
S-20	86.4	69.1	80	82.9	58.7	70.8
S-21	87	66.2	76.1	85	56.2	65.8
S-22	88.5	61	68.9	89.2	69.5	77.6
S-23	86.5	71.1	82.1	88.1	69.2	78.7
S-24	90.5	75.2	83.5	87.9	78	88.7
S-25	89.9	80.5	89.5	81.5	67.1	82.4
S-26	88.4	78.9	89.3	79.7	66.6	83.4
S-27	85.3	72.5	84.3	79.6	68.0	85.3

Gen.	IWD			IWF		
		Hatchability (%)			Hatchability (%)	
	Fertility (%)	TES	FES	Fertility (%)	TES	FES
S-28	76.0	66.0	87.2	68.5	66.2	82.0
S-29	81.2	70.7	87.1	69.8	52.1	74.6
S-30	71.6	56.1	78.3	83.5	73.2	87.7
S-31	86.5	77.2	89.2			

Mortality over the generations

The mortality pattern over the generations in IWD and IWF strains showed that in IWD line, mortality was highly reduced at 0-8, 9-20 and 21-40 weeks of age in S-31 generation but it was still quite high after 40 weeks of age i.e. at 41-64 and 21-64 weeks of age. In IWF line, a similar pattern was observed in S-30 generation of selection (Table 31). Due to no selection pressure in control population, mortality was quite low at all ages.

Table 31. Mortality (%) over the generations in IWD and IWF strains

Strain	Gen.	0-8 wk	9-20*/ 9-16 wk	21-40*/ 17-40 wk	41-64 wk	21-64*/ 17-64 wk
IWD	S-22	8.46	8.26*	7.85*	11.03	18.02*
	S-23	1.74	4.18	6.20	6.70	12.48
	S-24	6.62	5.41	13.18	13.78	25.14
	S-25	4.30	1.70	4.77	--	--
	S-26	1.14	1.46	6.63	4.53	10.85
	S-27	2.16	2.31	8.40	2.73	10.92
	S-28	3.98	4.49	4.59	5.48	10.05
	S-29	6.76	23.75	7.54	3.55	10.81
	S-30	8.13	17.10	21.73	6.70	26.93
	S-31	3.48	4.98	10.58	12.23	21.51
IWF	S-21	17.61	11.15*	10.11*	10.65*	19.69*
	S-22	3.44	8.53	12.00	9.95	20.76
	S-23	3.94	3.89	18.10	6.84	23.70
	S-24	4.89	1.95	5.18	--	--
	S-25	1.26	2.16	10.39	4.92	14.75
	S-26	3.33	2.50	12.34	2.90	14.89
	S-27	4.03	4.98	4.50	6.54	10.75
	S-28	12.83	27.10	5.76	2.08	7.73
	S-29	7.56	20.06	20.88	7.70	26.95
	S-30	3.65	4.90	8.99	11.94	19.86
Control	01-02	13.01	2.99*	8.08*	7.10*	14.65*
	02-03	1.53	1.94	4.89	3.43	8.15
	03-04	1.53	2.71	5.56	4.12	9.44
	04-05	3.81	1.49	4.31	--	--
	05-06	1.42	2.73	19.48	4.11	9.10
	07-08	4.27	4.83	12.88	1.88	13.92
	09-10	5.02	5.76	6.25	3.48	9.47
	10-12	2.85	21.52	1.42	1.44	2.86
	12-13	4.33	9.87	6.39	3.41	9.59
	13-14	0.39	6.56	4.30	3.36	7.53

Body weight and age at first egg

Age at first egg and BW20 weeks estimates were recorded upto S-24 generation in IWD and S-23 IWF line, thereafter, BW40 and BW60 were recorded in both the lines. The body weights showed a declining trend over the generations. The detailed summary of the AFE and body weight traits over the generations in IWD and IWF lines is presented in Table 32.

Table 32. Trend of age at first egg (d) and body weight (g) traits over the generations in IWD and IWF strain

Gen.	IWD				IWF			
	AFE	BW20	BW40	BW64	AFE	BW20	BW40	BW64
S-0	171	1090	1590	-	174	1300	1600	-
S-1	188	1100	1530	-	183	1170	1540	-
S-2	173	1120	1590	-	180	1080	1510	-
S-3	165	1221	1590	-	170	1200	1630	-
S-4	162	1265	1485	-	166	1182	1482	-
S-5	165	1157	1693	-	167	1212	1695	-
S-6	161	1227	1640	-	162	1079	1620	-
S-7	157	1198	1456	-	161	1143	1437	-
S-8	148	1299	1571+6.9	-	150	1276	1691	-
S-9	152	1162	1445	-	150	1126	1610	-
S-10	161	1096	1602	-	134	1268	1659	-
S-11	154	1254	1656	-	149	1257	1655	-
S-12	158	1192	1579	-	150	1278	1620	-
S-13	145	1282	1640	-	151	1241±2.5	1604±4.8	-
S-14	149	1277+2.9	1641+5.1	-	160±0.3	1192	1509	-
S-15	155	1265	1532	-	152±0.01	1239±3.1	1518±4.7	-
S-16	146+0.3	1316+3.4	1532+4.7	-	162±0.50	1136±0.11	1455±0.18	1629±0.02
S-17	153+0.01	1254+0.14	1503+0.16	-	154±0.47	1300±0.84	1580±6.13	1720±8.89
S-18	143+0.44	1410+5.18	1575+5.16	1736+6.65	157±0.18	1160±6.31	1570±6.40	1700±9.48
S-19	152+0.43	1230+6.15	1600+5.87	1722+7.51	156+0.12	1242±2.71	1633±3.75	1758±11.53
S-20	154+0.18	1329+2.51	1668+3.37	1813+4.57	151±0.27	1177±2.81	1554+4.13	1618±5.13
S-21	151+0.25	1195+2.7	1492+7.65	1678+5.02	160±0.27	1214±9.70	1552±4.70	1727±6.59
S-22	149+0.24	1316+9.94	1572+4.20	1716+5.49	156±0.18	1199±2.58	1515±3.55	1505±9.25
S-23	148+0.26	1311+2.55	1500+3.03	1504+7.0	157±0.18	1191±2.68	1384±3.17	1499±4.06
S-24	155+0.20	1269+0.29	1367+0.33	1466+3.71			1445	1479
S-25			1473	1506			1417	1503
S-26			1459	1520			1429	1447
S-27			1311	1447			1168	
S-28			1400				1224	
S-29			1249				1237	
S-30			1280	1309			1242	1315
S-31			1295	1323				

Egg production and egg weight traits

In IWD line, egg weights at 28 and 40 weeks of age have witnessed a declining trend over the generations while EW64 shows a fluctuating trend. The EP40 was 74 eggs in the base generation (S-0) which increased to 99 eggs after 17 generations of selection in IWD. In case of IWF the EP40 increased to 77 eggs in S-2 to 109 eggs in S-17 generation. The EP40 and EP64 traits showed a consistent improvement and increased to 113 and 232 eggs in S-24 generation (Table 33). Last generation of selection in IWF line reported almost similar estimates of egg weight as IWD, however, egg production at 40 and 64 weeks was marginally lower in the former as compared to the latter (Table 34). The trend of phenotypic and genetic response for EP64 for IWD and IWF lines is depicted in Figures 6 and 7 respectively.

Table 33. Trend of egg production and egg weight traits over the generations in IWD strain

Gen.	Egg weights (g)			EP40 wks (Nos.)			EP64 wks (Nos.)		
	EW28	EW40	EW64	HH	HD	HS	HH	HD	HS
S-18	-	56±0.12	-	100±1.0	101±0.68	105±0.51	-	-	-
S-19	50±0.10	56±0.12	-	92.3±0.90	98±0.96	100±0.59	210±2.03	212±2.17	214±0.96
S-20	49.8±0.06	56.7±0.09	-	102.5±0.28	103±0.25	103±0.23	208±1.33	215±0.56	213±0.48
S-21	47±0.07	54±0.07	-	101.5±0.29	102±0.28	-	213±0.71	217±0.70	217±0.64
S-22	47.2±0.19	52.9±0.07	-	108±0.33	109	110±0.30	228±0.78	233±0.43	233±0.71
S-23	48.2±0.07	53.3±0.07	54.7±0.09	111±0.32	112	112±0.31	231±0.68	236±0.32	236±0.61
S-24	48.2±0.07	54.7±0.07	58.1±0.25	113±0.22	113	115±0.32	232±0.67	237±0.57	237±0.58
S-25	48.8	53.1	55.2						
S-26	50	54.3	56						
S-27	47.6	50.2	54.5						
S-28	46.8	51.2					231	NR	NR
S-29	47.32	50.21					235	NR	NR
S-30	46.6	50.3	56.0						
S-31	48.0	50.7	56.5	NA	NA	106±0.47	230	NR	NR

Table 34. Trend of egg production and egg weight traits over the generations in IWF strain

Gen.	Egg weights (g)			EP40 wks (Nos.)			EP64 wks (Nos.)		
	EW28	EW40	EW64	HH	HD	HS	HH	HD	HS
S-18	50±0.11	53	-	90.8	99	101±0.52	221±0.73	221±0.95	231±0.51
S-19	49±3.5	53	-	107	108	110±0.22	223±0.95	223±0.51	233±0.60
S-20	46±0.10	52.6±0.10	-	105±0.68	105.5±0.25	106±0.28	225±0.64	229±0.44	229±0.60
S-21	47.2±0.23	51.1±0.07	-	106	109	109±0.32	237±0.54	237±0.89	244±0.72
S-22	48.3±0.67	53.1±0.07	54±0.09	110	111±0.33	112	239±0.02	241±0.04	242±0.72
S-23	48.3±0.67	53±0.07	57±0.30	111	112	113±0.41	242±0.41	243±0.62	244±0.71
S-24	49.7	53.3	54.5						
S-25	49.6	54.6	54.8						
S-26	47.5	50.0	54.0						
S-27	46.3	50.4					233	NR	NR
S-28	47.5	50.1					234	NR	NR
S-29	47.9	51.1	54.3						
S-30	48.1	52.0	56.1	NA	NA	111±0.40	230	NR	NR

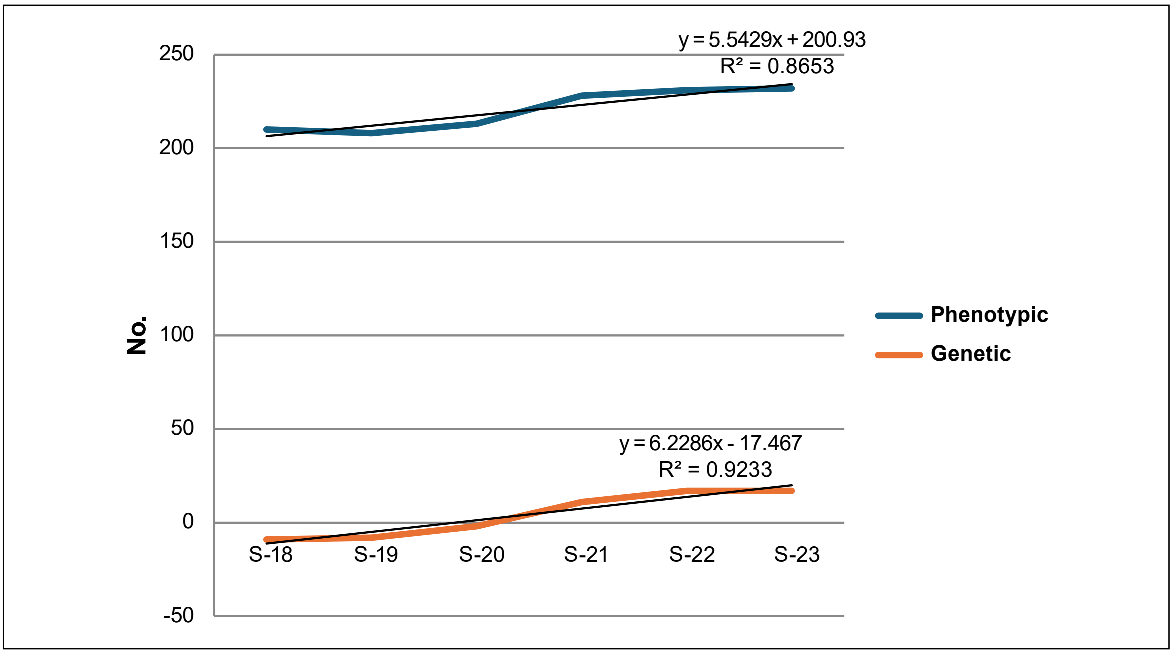


Figure 6: Trend of phenotypic and genetic response for EP64 over the generations in IWD strain

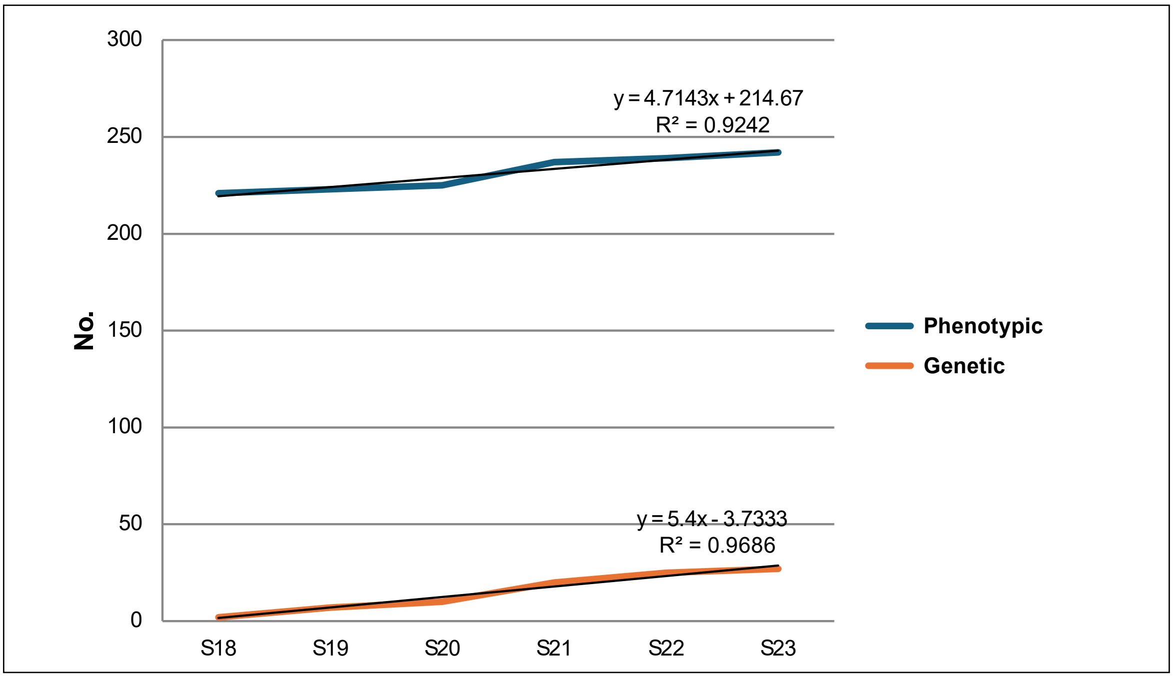


Figure 7: Trend of phenotypic and genetic response for EP64 over the generations in IWF line

Egg quality traits

Egg quality traits like yolk index, Haugh unit, Albumen index, shell thickness, meat spot (%) and blood spot (%) were also recorded over the generations in IWD and IWF lines (Tables 35 and 36). In S-29 generation in IWD line, yolk index was 0.36, Haugh unit was 71.69, albumen index was 0.07 and shell thickness was 0.34. In IWF line, yolk index was 0.35, Haugh unit 67.4, albumen index was 0.06 and shell thickness was 0.34 in S-28 generation.

Table 35. Performance of egg quality traits over the generations in IWD strain

Gen.	Yolk Index	Haugh Unit	Alb. Index	Shell thickness (mm)	Blood spots (%)
S-2	0.42	84	-	0.38	-
S-3	-	76.1	0.076	0.39	-
S-4	-	82	0.09	0.38	5
S-5	-	79	0.09	0.37	7
S-6	-	78.25	0.084	0.36	5.1
S-7	-	81.5	0.08	0.37	6.66
S-8	-	77.2	0.08	0.33	3.5
S-9	-	73.1	0.07	0.36	7.03
S-11	-	76.1	0.08	0.34	7.53
S-12	-	59.4	0.05	0.36	13
S-13	-	55.8	0.05	0.35	13
S-14	-	55.7	0.04	0.36	3
S-15	-	63.8	0.06	0.36	8
S16	0.45	77.5	0.07	0.34	3
S-17	-	73	5.61	0.34	3
S-18	0.44	73	0.07	0.34	4
S-19	0.41	68	0.05	0.35	4.5
S-20	0.41	66.2	0.05	0.36	5
S-21	-	60.8	-	0.36	-
S-22	-	66.8	0.07	0.34	-
S-23	-	67.6	0.58	0.4	-
S-24	-	66.7	0.05	0.42	-
S-25	0.40	80.4	0.05	0.35	
S-26	0.42	62.74	0.06	0.34	
S-27	0.43	67.16	0.06	0.34	
S-28	0.42	62.74	0.06	0.34	
S-29	0.36	71.69	0.07	0.34	

Table 36. Trend of egg quality traits over the generations in IWF strain

Gen.	Yolk Index	Haugh Unit	Alb. Index	Shell thickness (mm)	Blood spot(%)
S-2	0.41	85	-	0.39	-
S-3	-	72	0.07	0.39	
S-4	-	86	0.1	0.38	2
S-5	-	79	0.08	0.39	-
S-6	-	78.7	0.08	0.33	1
S-7	-	81.8	0.08	0.37	2.5
S-8	-	75.8	0.07	0.37	1.5
S-9	-	74.1	0.07	0.36	4
S-10	-	71.1	0.07	0.34	1.51
S-11	-	58.2	0.05	0.35	4
S-12	-	56.7	0.05	0.35	6
S-13	-	56.3	0.51	0.36	7.57
S-14	-	64	0.56	0.36	5.8
S-15	0.45	73	0.07	0.34	4
S-16		73	5.06	0.33	1
S-17	0.45	72	0.06	0.34	
S-18	0.42	68	0.05	0.33	3

Gen.	Yolk Index	Haugh Unit	Alb. Index	Shell thickness (mm)	Blood spot(%)
S-19	4	60.5	0.04	0.34	-
S-20	-	57.4	-	0.36	-
S-21	-	65.3	0.06	0.33	-
S-22	-	66.8	0.59	0.39	-
S-23	-	65.7	0.05	0.4	-
S-24	0.42	69.5	0.06	0.34	-
S-25	0.38	56.7	0.05	0.34	
S-26	0.41	64.44	0.06	0.34	
S-27	0.40	77.1	0.05	0.31	
S-28	0.35	67.4	0.06	0.34	

The performance of crosses (IWDxIWF) was evaluated during the year 1981-82. The estimates for AFE, BW20, BW40, EW40 and EP72 weeks were recorded as 132 days, 1168 (g), 1759 (g), 53.6 (g) and 229 eggs respectively.

Genetic parameters estimation

The heritability estimates for different traits in IWD and IWF lines are presented in Tables 37-39. The heritability estimates for EP40 and EW40 weeks were same for both the lines while estimates for EP64 were higher in IWF line as compared to IWD. As far as the trait age at first egg was concerned, the heritability based on sire component as negative (-0.03) in IWF line while IWD line showed high heritability estimate (0.36). However, surprisingly, the trait body weight at 20 weeks (BW20) reported very low heritability estimates (based on sire component) in both IWD and IWF lines.

Table 37. Heritability estimates for egg production and egg weight traits in IWD strain

Gen.	EP40			EP64			EW40		
	S	D	S+D	S	D	S+D	S	D	S+D
S-2	0.29±0.15	-	-	-	-	-	-	-	-
S-3	0.42±0.13	-	-	-	-	-	-	-	-
S-4	0.26±0.10	-	-	-	-	-	0.39±0.13	-	-
S-5	0.13±0.08	-	-	-	-	-	0.97±0.26	-	-
S-6	0.25±0.09	-	-	-	-	-	0.79±0.20	-	-
S-7	0.21±0.12	-	-	-	-	-	0.83±0.25	-	-
S-8	0.18±0.08	-	-	-	-	-	0.18±0.10	-	-
S-9	0.06±0.06	-	-	-	-	-	0.53±0.05	0.16±0.05	0.26±0.03
S-10	-	-	-	-	-	-	0.38±0.00	-	-
S-11	-	-	-	-	-	-	0.21±0.00	-	-
S-12	0.42±0.07	-	-	-	-	-	0.30±0.03	-	-
S-13	0.24	0.16	0.22	-	-		0.55	0.23	0.39
S-14	0.24	0.05	0.15	-	-		0.53	0.47	0.49
S-15	-0.02±0.03	0.09±0.08	0.03±0.04	-	-		0.16±0.00	0.49+0.01	0.32±0.00
S-16	0.07	0.09	0.03	-	-		0.31	0.21	0.16
S-17	0.12±0.09	-	0.26±0.07	0.13±0.08		0.22±0.07	0.13±0.10	-	0.38±0.08
S-18	0.56±0.16	-	0.36±0.09	0.51±0.15		0.29±0.09	0.59±0.18	-	0.46±0.10
S-19	0.20±0.11	-	0.20±0.10	0.29±0.12	0.07±0.09	0.11±0.10	0.44±0.16	0.32±0.12	0.27±0.11
S-20	0.16±0.05	-	0.017±0.04	0.27±0.07	0.07±0.05	0.17±0.04	0.71±0.06	0.11±0.17	0.50±0.09
S-21	0.14±0.06	-	0.24±0.05	0.15±0.06	0.24±0.08	0.20±0.04	0.42±0.12	0.29±0.16	0.13±0.04
S-22	0.24±0.07	-	0.17±0.05	0.13±0.07	0.02±0.06	0.07±0.04	0.21±0.04	0.50±0.09	0.40±0.01
S-23	0.22±0.08	-	0.32±0.05	0.34±0.12	0.39±0.13	0.56±0.08	0.54±0.14	0.43±0.08	0.48±0.08
S-24	0.10±0.06	-	0.12±0.06	0.16±0.07	0.16±0.11	0.11±0.05	0.51±0.14	0.39±0.12	0.45±0.09
S-27	0.20±0.06	0.12±0.08	0.14±0.05	0.21±0.07	0.05±0.09	0.08±0.05	0.31±0.09	0.35±0.09	0.39±0.09
S-28	0.16±0.07	0.05±0.10	0.10±0.05	0.12±0.06	0.10±0.10	0.008±0.05	0.44±0.13	0.27±0.11	0.36±0.05

Table 38. Heritability estimates for egg production and egg weight traits in IWF strain

Gen.	EP40			EP64			EW40		
	S	D	S+D	S	D	S+D	S	D	S+D
S-2	0.38±0.19	-	-	-	-	-	-	-	-
S-3	0.25±0.11	-	-	-	-	-	-	-	-
S-4	0.36±0.12	-	-	-	-	-	0.40±0.14	-	-
S-5	0.29±0.11	-	-	-	-	-	0.72±0.21	-	-
S-6	0.09±0.06	-	-	-	-	-	0.68±0.20	-	-
S-7	0.28±0.10	-	-	-	-	-	0.71±0.19	-	-
S-8	0.11±0.07	-	-	-	-	-	0.63±0.20	-	-
S-9	0.21±0.10	-	-	-	-	-	0.46±0.15	0.18±0.05	0.33+0.01
S-10	-	-	-	-	-	-	0.45±0.00	-	-
S-11	-	-	-	-	-	-	0.31±0.00	-	-
S-12	0.15	0.23	0.19	-	-	-	-0.03	0.75	0.36
S-13	0.42	0.02	0.31	-	-	-	0.56	0.2	0.38
S-14	0.27±0.09	0.11±0.07	0.19±0.06	-	-	-	0.33±0.01	0.04±0.00	0.14+0.00
S-15	0.08	-0.02	0.03	-	-	-	0.04	0.25	0.32
S-16	0.22±0.11	-	0.27±0.08	0.32±0.12	-	0.28±0.08	0.18±0.10	-	0.25+0.07
S-17	0.31±0.13	-	0.22+0.09	0.09±0.10	-	0.26±0.09	0.54±0.20	0.54±0.17	0.54+0.12
S-18	0.18±0.11	0.07±0.19	0.12+0.10	0.07±0.09	0.04±0.19	0.06±0.09	0.37±0.16	0.26±0.19	0.32+0.11
S-19	0.19±0.06	0.16±0.07	0.18+0.05	0.17±0.07	0.03±0.08	0.23±0.05	0.36±0.11	0.49±0.09	0.42+0.07
S-20	0.15±0.06	0.08±0.07	0.12+0.04	0.13±0.05	0.03±0.07	0.08±0.04	0.26±0.09	0.42±0.09	0.34+0.07
S-21	0.14±0.07	0.14±0.11	0.14+0.06	0.06±0.05	0.03±0.10	0.05±0.05	0.28±0.09	0.09±0.10	0.19+0.06
S-22	0.17±0.06	0.15±0.07	0.16±0.04	0.20±0.08	0.03±0.11	0.12±0.06	0.36±0.10	0.18±0.07	0.27±0.05
S-23	0.23±0.08	0.20±0.09	0.21±0.05	0.10±0.05	0.22±0.09	0.16±0.05	0.38±0.07	0.26±0.09	0.32±0.05
S-26	0.22±0.06	0.15±0.07	0.17±0.10	0.03±0.04	0.22±0.10	0.005±0.08	0.36±0.09	0.10±0.08	0.12±0.06
S-27	0.16±0.07	0.05±0.10	0.10±0.05	0.16±0.07	0.09±0.11	0.13±0.06	0.44±0.13	0.26±0.11	0.36±0.08

Table 39. Heritability estimates for age at first egg and body weight traits in IWD and IWF strain

Gen.	IWD				IWF			
	AFE	BW20			AFE	BW20		
	S	D	S+D	S	S	D	S+D	S
S-2	0.19±0.12	-	-	0.44±0.11	0.33±0.20	-	-	0.55±0.27
S-3	0.37±0.13	-	-	0.45±0.13	0.49±0.15	-	-	0.31±0.13
S-4	0.42±0.12	-	-	0.24±0.11	0.42±0.14	-	-	0.48±0.16
S-5	0.43±0.14	-	-	0.50±0.16	0.53±0.15	-	-	0.41±0.14
S-6	0.30±0.11	-	-	0.36±0.11	0.30±0.11	-	-	0.81±0.21
S-7	0.55±0.09	-	-	0.47±0.16	0.37±0.13	-	-	0.69±0.20
S-8	0.12±0.09			0.36±0.14	0.28±0.10			0.34±0.14
S-9	0.01±0.01	0.29±0.04	0.17±0.02	0.28±0.12	0.33±0.13	0.16±0.04	0.25±0.02	0.29±0.14
S-10	0.16±0.01	-	-	-	0.15±0.01	-	-	0.37±0.01
S-11	0.19±0.01	-	-	-	0.19±0.01	-	-	-
S-12	0.20±0.01	-	-	-	0.40±0.01	0.44	0.42	0.46
S-13	0.44	0.25	0.34	0.21	0.33	0.21	0.25	0.26
S-14	0.31	0.24	0.28	0.44	0.18±0.04	-0.09+0.04	0.04±0.03	0.26±0.00
S-15	0.15±.04	0.07±0.06	0.11±0.04	0.27±0.00	0.19	0.18	0.19	0.45

Gen.	IWD				IWF			
	AFE	BW20			AFE	BW20		
	S	D	S+D	S	S	D	S+D	S
S-16	0.24	0.29	0.26	0.31	0.37±0.13	-	0.31±0.08	0.03±0.11
S-17	0.28±0.11	-	0.30±0.08	0.22±0.10	0.47±0.16	0.12±0.15	0.03±0.10	0.34±0.16
S-18	0.33±0.16	0.22±0.12	0.38±0.09	0.16±0.08	0.08±0.08	0.20±0.18	0.06±0.09	0.12±0.10
S-19	0.01±0.06	0.06±0.19	0.04±0.09	0.27±0.12	0.24±0.08	0.22±0.08	0.23±0.05	0.20±0.08
S-20	0.12±0.04	0.14±0.06	0.13±0.03	0.10±0.04	0.23±0.08	0.39±0.08	0.31±0.05	0.20±0.07
S-21	0.23±0.08	0.39±0.09	0.31±0.05	0.10±0.05	0.27±0.09	0.09±0.10	0.09±0.06	0.21±0.09
S-22	0.06±0.04	0.16±0.07	0.11±0.04	0.17±0.07	0.22±0.07	0.079±0.10	0.22±0.05	0.44±0.12
S-23	0.22±0.07	0.27±0.07	0.25±0.05	0.22±0.07	0.18±0.06	0.17±0.09	0.17±0.05	0.07±0.05
S-24	0.19±0.08	0.22±0.12	0.21±0.06	0.44±0.13				
S-26					-0.03±0.03	0.15±0.11	0.06±0.09	
S-27	0.39±0.09	0.16±0.06	-0.06±0.09	0.05±0.04				
S-28	0.36±0.05							

Response to selection

The phenotypic response to EP64 (direct) was 9.49 eggs in IWN and 8.65 eggs in IWP in the last 4 generations (Table 40) and were significant. The phenotypic response for egg weight in IWN and IWP are positive and significant (but low in magnitude) and are in the desirable direction. The phenotypic response for egg production to 40 and 64 weeks of age in IWN was larger than IWP and is desirable for the population being used as the male parent of ILM-90 cross.

Table 40. Phenotypic response in primary and correlated traits

Traits	Strains		Strain	
	IWN	IWP	IWN	IWP
Egg production up to 64 weeks (Nos.) 18-21 gen	9.49 ± 3.37	8.65 ± 2.12	0.04 ±0.25	0.21 ± 0.10
Egg production up to 40 weeks(Nos.) 1-21 gen	1.73 ± 0.30	1.71 ± 0.25	0.16± 0.12	0.22 ± 0.11
Egg weight at 40 weeks(g) 1-21 gen	0.10 ± 0.03	0.10 ± 0.03	0.16 ± 0.18	0.22 ± 0.16
Body weight at 16 weeks(g) 18-21 gen	48.13 ± 7.17	54.68 ± 17.73	0.74 ± 0.66	1.12 ± 2.00
Body weight at 40 weeks(g) 1-21 gen	7.74 ± 2.36	9.51 ± 3.24	0.16 ± 0.26	0.47 ± 0.41
Average Age at first egg (d) 18-21 gen	-0.92 ± 0.02	-1.10 ± 0.23	0.44 ± 0.16	0.41 ± 0.10

The average genetic response to selection (direct) for EP64 was 0.04 (non-significant) in IWN and 0.21 in IWP (significant). The correlated genetic response for the secondary traits is presented as follows (Table 40). The genetic response to egg weight at 40 weeks of age was positive in both the strains but non-significant. The average genetic response for EP64 over the last six generations was positive for both the lines.

Time trend in control population

The generation-wise phenotypic trend was positive for EP40 in both the lines for last two generations of selection while it was mostly negative for the control population. For EW40, phenotypic response was positive for IWD line and control population in the last two generations while it was not reported for IWF line. The average phenotypic response of AFE and different body weights in IWD and IWF and their time trend in control population also fluctuated in positive and negative directions in different generations (Table 41).

Table 41. Generation-wise phenotypic response in IWD and IWF and time trend in control population over generations

Gen.	EP40			EW40			AFE			BW20			BW40		
	IWD	IWF	CON	IWD	IWF	CON	IWD	IWF	CON	IWD	IWF	CON	IWD	IWF	CON
S-1	-	-	-	0	0	-	17	9	-	10	130	-	-60	-60	-
S-2	-	-	-	-1	-1	-	-15	-3	-	20	-90	-	60	-30	-
S-3	-1	-1	-	0	1	-	-8	-10	-	101	120	-	0	120	-
S-4	2	1	-	0	1	-	-3	-4	-	44	-18	-	-105	-148	-
S-5	0	1	-	-1	-1	-	3	1	-	-108	30	-	208	213	-
S-6	0	0	-	-3	-1	-	-4	-5	-	70	-133	-	-53	-75	-
S-7	6.7	4.8	-	3	-4	-	-4	-1	-	-29	64	-	-184	-183	-
S-8	-2.5	-1.1	-	0	4	-	-9	-11	-	101	133	-	115	254	-
S-9	2.5	0.3	-	-1	-1	-	4	0	-	-137	-150	-	-126	-81	-
S-10	0.7	6.1	-	1	2	-	9	-16	-	-66	142	-	157	49	-
S-11	3.8	-0.4	-	1	1	-	-7	15	-	158	-11	-	54	-4	-
S-12	0	10.5	-	2	2.3	-	4	1	-	62	21	-	-77	-35	-
S-13	6.1	-2.7	-	1	-1.3	-	-13	1	-20.7	90	-37	-	61	-16	-
S-14	0	-5.9	1	1	-0.2	3.7	4	9	14.7	-5	-49	-3	1	-95	192
S-15	-1.8	3.5	-9	-1	-0.8	-6.6	6	-8	4	-12	47	130	-109	9	-138
S-16	2.4	-0.1	8	0.8	-3	0.9	-9	10	-	51	-103	33	0	-63	-26
S-17	0.1	4.7	11	-2.1	4	-1.1	7	-8	-1.7	-62	164	-216	-29	125	-105
S-18	2	-11.3	-10	5	-1	2.9	-10	3	-	156	-140	179	72	-10	-28
S-19	-7.7	16.2	3	0	0	1.6	9	-1	-1	-180	82	-100	25	63	100
S-20	10.2	-2	-13	0.7	-1.5	1	2	-5	-	99	-65	144	68	-79	120
S-21	-1	1	9	-2.7	2	-1	-3	9	-1	-134	37	-100	-176	-2	-26
S-22	6.5	4	-2	-1.1	-0.1	-3	-2	-4	2	121	785	9	80	-37	-53
S-23	3	1	-4	0.4	-	3	-1	1	5	-5	-808	6	-72	-131	-137
S-24	2	-	12	1.4	-	0	7	-	2	358	-	-9	-133	-	-100

Random Sample Poultry Performance Test (RSPPT) Results of IWD x IWF

The Random Sample Poultry Performance test of IWD x IWF strains errors is presented in Table 42. This reveals that hen housed egg production decreased from 235 to 227.9 in number from 1980 to 1986-87 in Bangalore Centre and thereafter, the strain cross performance increased to 265.8 in number in the year 2001-02 in the same centre. The egg production performance of RSPPT in Mumbai centre was better as compared to Bangalore Centre. The feed consumption per dozen of eggs varied from 1.49 to 3.47 in different centres and mostly, it was around 2.10. The average egg weight was also good (Table 42).

Table 42. Random Sample Poultry Performance Test (RSPPT) Results of ILR-90 Jubilee (IWD x IWF)

Year	Centre	HHEP (Nos.)	HDEP (Nos.)	Feed consumed per dozen of egg (kg.)	Feed Consumption per bird per day (g)	Egg wt (g)
1980	Bangalore	235.0	244.3	1.95	-	52.4
1981	Bangalore	244.3	235	-	110.0	50.9
1982	Bombay	229.0	246.0	-	96.0	51.0
1983	Bombay	234.0	236.0	-	99.0	52.0
	Bangalore	217.8	224.9	-	114.0	51.3
	Bhubaneswar	224.7	227.5	-	105.0	50.8
1984	Bombay	243	249.0	-	124.0	52.0
	Bangalore	243.0	248.4	-	109.0	51.1
	Bhubaneswar	207.0	218.9	-	113.0	51.9
1986-87	Bangalore	227.9	228.3	-	113.0	53.6
	Anand	225.1	238.1	-	101.3	53.8
1989-90	Bangalore	247.2	251.3	2.27	-	60.6
	Bhubaneswar	227.6	233.4	2.22	-	51.8
1990-91	Bombay	243.5	245.2	2.02	-	57.9
	Bangalore	246.8	272.4	2.22	-	54.3
	Bhubaneswar	235.7	243.8	2.10	-	52.3
1992-93	Bombay	205.0	219.0	3.47	-	55.0
	Bangalore	225.0	238.0	2.14	-	54
1993-94	Bombay	222	228	2.39	-	56
	Bhubaneswar	225	232	2.06	-	51
1994-95	Mumbai	236.0	243.0	2.13	-	55
1997-98	Mumbai	255.7	256.9	1.70	99.99	51.05
	Bangalore	223.5	243.1	2.14	117.0	55.9
1998-99	Mumbai	288.2	289.2	1.49	96.2	49.1
1999-2000	Mumbai	245.7	248.3	2.09	114.0	50.1
	Bangalore	252.5	259.9	2.11	119.0	56.3
2001-02	Mumbai	285.5	286.5	1.57	101.9	50.1
	Bangalore	265.8	277.6	1.96	118.0	57.1
2002-03	Mumbai	250.5	256.5	2.21	123.5	50.6

4 ICAR - Central Avian Research Institute, Izatnagar (Egg)

At CARI, Izatnagar, the selection programme was carried out on four exotic strains of WLH, *viz*. IWG, IWH, IWI and IWJ populations along with a random bred control population. ICARI centre was assigned to maintain two selected lines *viz*., IWH and IWI and one control population. The IWG and IWJ would be maintained on a small population size. Selection would be practiced for IWH and IWI for egg production up to 64 wks of age. Selection would also be practiced for layer house viability, egg weight at 28 wks and body weight at 16 wks. The centre was discontinued from 2013.

Achievements

The centre has evaluated the IWH, IWI strains and a control population up to 64 weeks of age in S-32 generation. Intra-population selection method was used to select the parents for this generation using Osborne Index for egg production up to 64 weeks of age in IWH and IWI lines.

Selection records

During the last five generations, the effective population size in both IWH and IWI lines has been maintained at 165. 50 males and 273 females of IWH and 49 males and 265 females of IWI contributed to the gene pool in S-31 (last) generation of selection. The average selection differential for egg production was 28.29 and 26.55 while the average intensity of selection was 0.55 and 0.42 in IWH and IWI lines respectively. The complete summary of selection is detailed in Table 43.

Table 43. Summary of selection record during last five generations at CARI centre

Strains	Gen.	Sires contributed	Dams contributed	Ne	SD for egg production	Intensity of selection
IWH	S-27	49	298	168	16.11	0.48
	S-28	49	297	168	32.75	0.68
	S-29	49	296	168	30.67	0.60
	S-30	49	298	168	34.2	0.47
	S-31	50	273	169	27.76	0.51
IWI	S-27	48	297	165	21.96	0.59
	S-28	49	298	168	32.48	0.66
	S-29	49	297	168	24.19	0.43
	S-30	49	296	168	29.25	0.41
	S-31	49	265	165	24.87	0.44

Incubation records

The fertility percentage witnessed a decline in all the lines in S-32 generation (last generation of selection) and plummeted below 80 percent. Hatchability based on total eggs and fertile eggs was highest in control line followed by IWH and IWI lines. The hatchability values showed an improvement in S-32 generation over the previous two generations of selection. Incubation records of past several generations of IWH, IWI and control populations and WHL strain crosses have been presented in Table 44.

Mortality over the generations

Analysis of mortality rates revealed that there was a significant increase in the 0-8 weeks age group during S-32 generation of selection in all the lines. Similarly, at 9-16 weeks of age, a slight increase in mortality was noticed over the previous generation. Though the data for 17-40 weeks, 41-64 weeks and 17-64 weeks age group is not available for the last generation, the previous generations data shows a fluctuating trend (Table 45).

Table 44. Summary of incubation records for IWH, IWI and Control strains over the generations

Gen.	IWH			IWI			Control		
		Hatchability (%)			Hatchability (%)			Hatchability (%)	
	Fertility (%)	TES	FES	Fertility (%)	TES	FES	Fertility (%)	TES	FES
S-24	86.92	47.86	55.06	87.06	49.53	56.89	87.35	53.62	61.38
S-25	87	42	48	87	46	53	88	54	61
S-26	84	48	57	85	50	59	86	58	67
S-27	89.22	63.26	70.91	91.5	69.65	76.12	92.44	72.62	78.56
S-28	91.69	55.07	73.02	91.82	63.19	81.68	92.41	66.71	83.41
S-29	91.61	65.49	71.48	88.28	55.41	62.77	90.22	60.74	67.32
S-30	89.12	55.95	62.78	85.67	53.81	62.81	90.96	68.54	75.35
S-31	89.84	55.13	61.36	87.35	50.28	57.56	86.42	50.62	58.57
S-32	79.10	60.12	76.01	75.11	55.51	73.91	76.35	62.19	81.45

Table 45. Mortality (%) of IWH, IWH and control populations over the generations

Strain	Gen.	0-8 wks	9-16 wks	17-40 wks	41-64 wks	17-64 wks
IWH	S-25	15.2	4.06	11.38	0.82	12.13
	S-26	3.62	7.32	9.78	2.71	12.23
	S-27	8.60	27.23	13.02	-	-
	S-28	2.54	5.03	-	-	-
	S-29	7.90	9.26	8.26	4.76	13.04
	S-30	7.63	6.14	28.94	7.29	-
	S-32	16.11	6.65	-	-	-
IWI	S-25	12.59	3.73	9.17	0.20	9.35
	S-26	3.67	5.54	8.40	3.92	11.99
	S-27	4.20	11.63	14.32	-	-
	S-28	2.95	5.23	-		-
	S-29	10.48	8.25	7.53	5.52	13.25
	S-30	8.51	6.13	28.91	9.62	-
	S-32	18.53	7.22	-	-	-
Control	S-25	10.10	5.58	10.79	0.99	11.69
	S-26	5.56	8.97	17.20	2.31	19.11
	S-27	5.13	24.65	12.68	-	-
	S-28	2.91	4.83	-	-	-
	S-29	11.77	10.53	6.95	5.07	12.76
	S-30	6.82	6.43	29.05	6.89	-
	S-32	31.49	6.79	-	-	-

Body weights and age at sexual maturity

During the past several generations, a fluctuating trend was noticed with body weights at 16 weeks, 40 weeks and 64 weeks showing an overall decline in the last generation. As far as the age at sexual maturity was concerned, the average value during the past five generations was 144.13, 147.92 and 164.23 days for IWH, IWI and control lines respectively. However, in S-32 generation, ASM witnessed an increase which is not desirable (Table 46).

Table 46. Trend of body weights and age at sexual maturity in different strains over the generations

Trait	Gen.	IWH	IWI	Control
BW 16 (g)	S-24	1181	1090	1118
	S-25	900	926	921
	S-26	922	927	950
	S-27	809	817	926
	S-28	1040	1068	1098
	S-29	873	918	873
	S-30	970	966	999
	S-31	1021	1030	1045
	S-32	1009	995	1019
BW 40 (g)	S-24	1374	1440	1510
	S-25	1256	1336	1496
	S-26	1255	1284	1432
	S-27	1357	1477	1582
	S-28	1412	1425	1564
	S-29	1447	1510	1597
	S-30	1329	1364	1491
	S-31	1315	1337	1500

Trait	Gen.	IWH	IWI	Control
BW 64 (g)	S-24	1582	1618	1725
	S-25	1394	1352	1562
	S-26	1447	1487	1605
	S-27	1372	1493	1628
	S-28	1568	1591	1714
	S-29	1556	1635	1735
	S-31	1440	1461	1622
ASM (days)	S-24	134.0	144.0	164.0
	S-25	136.6	141.2	149.5
	S-26	148.6	152.2	161.5
	S-27	141.9	147.6	163.5
	S-28	141.3	146.1	160.1
	S-29	140.14	145.32	163.77
	S-30	145.64	151.33	168.53
	S-31	144.47	145.75	160.06
	S-32	149.1	151.1	168.7

Egg production and egg weight traits

The different egg weight and production traits measured over the generations are presented in Tables 47 and 48. IWI line reported higher estimates for EW28 as compared to IWH and control populations. Similarly, EW40 and EW64 trait estimates were higher in the IWH as compared to the other two populations. The trend of egg production, both EP40 and EP64 have been decreased in both IWH and IWI lines. However, the average egg production at 40 and 64 weeks was higher in IWH, (101.59 and 219 respectively), line as compared to IWI (96.73 and 205.94 respectively). The trend of phenotypic and genetic response (Figures 8 and 9) showed a decline in EP64 after S-23 generation.

Table 47. Trend of egg weight traits in different lines over the generations

Gen.	EW 28 (g)			EW 40 (g)				EW 64 (g)	
	IWH	IWI	Control	IWH	IWI	Control	IWH	IWI	Control
S-24	46.9	49.6	49.5	56.8	58.9	60.9	56.8	54	56.4
S-25	47.9	49.9	51.89	55.52	57.41	59.32	56.9	58.5	61.1
S-26	49.3	51.4	51.30	54.4	54.6	56.9	56.9	56.3	57.8
S-27	44.85	46.53	46.83	52.26	54.31	55.41	52.6	52.8	55.8
S-28	48.09	50.35	49.83	49.92	52.17	52.44	56.47	58.71	57.80
S-29	45.98	49.39	49.19	53.12	54.54	55.23	55.85	55.26	57.18
S-30	44.79	46.51	47.30	50.98	50.47	52.19	-	-	-
S-31	46.73	48.07	47.64	51.00	52.64	52.08	58.00	58.23	56.67
S-32	47.02	48.03	47.58	-	-	-	-	-	-

Table 48. Performance of egg production (Nos.) traits in different strains over the generations

Gen.	IWH		IWI		Control	
	EP40	EP64	EP40	EP64	EP40	EP64
S-24	104.2	210	96.7	185	75.2	163
S-25	103.19	184	99.54	172	80.66	147
S-26	99.14	192	86.90	172	75.15	152
S-27	103.27	216	98.18	209	75.54	173.3
S-28	109.92	229	103.13	220	80.79	183
S-29	111	243	101	227	82	201
S-30	87.09	188	85.44	191	67.97	151
S-31	96.70	-	95.92	182.71	74.95	147.89

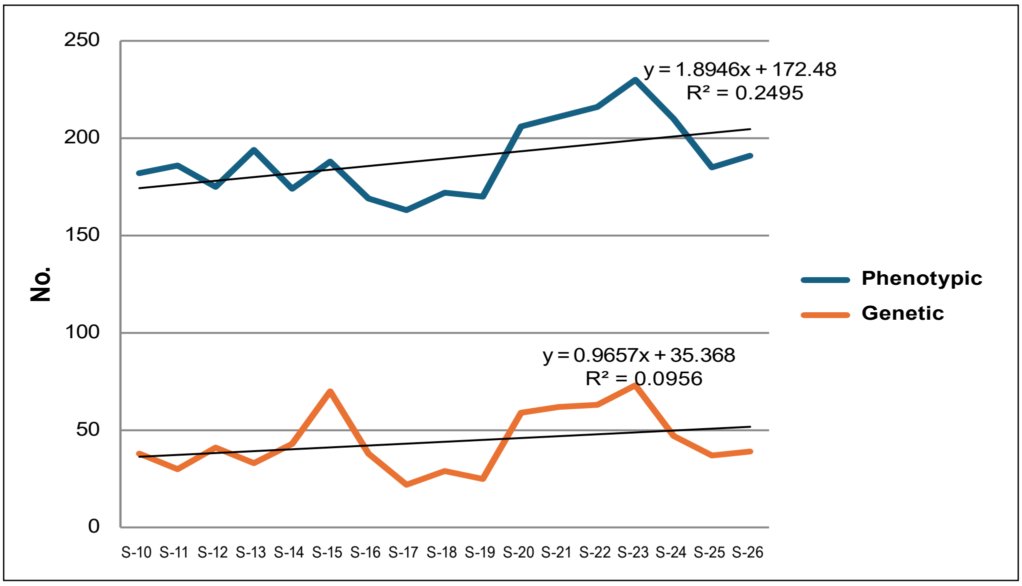


Figure 8: Trend of phenotypic and genetic response for EP64 over the generations in IWH line

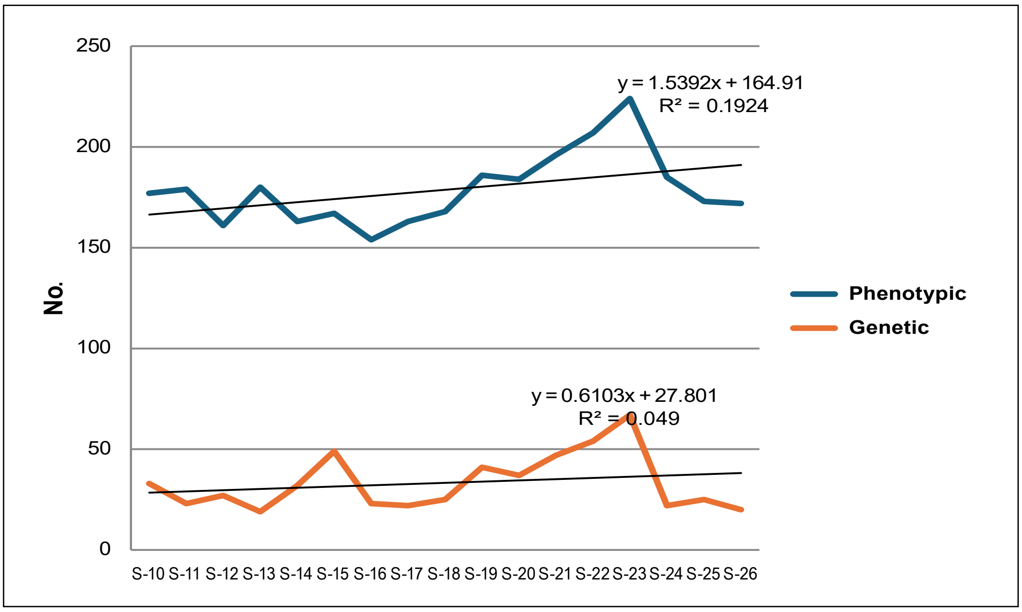


Figure 9: Trend of phenotypic and genetic response for EP64 over the generations in IWI line

Egg quality traits

Evaluation of egg quality traits performance indicated that there was not much change in shell thickness (mm) trait for the lines under selection. Moreover, there was almost no difference in shell thickness between all the lines. However, Haugh unit score declined whereas yolk index increased over the generations in IWH and IWI lines. Albumen index was higher for IWI line (8.47) as compared to IWH (7.92) and control lines (7.92) in S-31 generation (Table 49).

Table 49. Trend of egg quality traits of pure strains over the generations

Traits	Gen.	IWH	IWI	Control
Shell thickness (mm)	S-27	0.36	0.36	0.35
	S-28	-	-	-
	S-29	0.33	0.34	0.35
	S-30	0.36	0.40	0.39
	S-31	0.33	0.34	0.33
Haugh Unit	S-27	78.05	85.79	84.08
	S-28	-	-	-
	S-29	85.05	79.79	87.08
	S-30	76.59	71.45	71.99
	S-31	77.05	79.58	77.14
Albumen Index	S-27	8.95	9.65	8.94
	S-28	-	-	-
	S-29	8.12	8.14	7.12
	S-30	7.87	5.78	7.17
	S-31	7.92	8.47	7.92
Yolk Index	S-27	43.1	42.5	43.11
	S-28	-	-	-
	S-29	44.83	42.83	43.10
	S-30	39.87	38.72	38.52
	S-31	46.79	45.74	46.71

Performance of strain crosses

The performance of strain crosses (HI) for economic traits like body weights at 20, 40 and 64 weeks, age at sexual maturity, egg weight at 28 (or 32), 40 and 64 weeks and egg production at 40 and 64 weeks over the generations has been elucidated in Table 50.

Table 50. Performance of strain crosses (HI) over the generations

Strain	No. of birds	Body weight (g)			ASM (days)	Egg wt (g)			Egg Production to 280 days	
		20/16 wks	40 wks	64 wks		32/28 wks	40 wks	64 wks	40 wks	64 wks
1978-79										
HI	30	1152.0±37.01	1466.8±49.56	-	158.1± 4.80	-	54.5± 0.66	-	81.6± 4.19	-
1995-96										
HI	143	1401.77±9.98	1698.94±15.76	-	130.00±0.52	50.74±0.23	53.96±0.30	-	120.52±0.93	-
1996-97										
HI	82	1253.79±17.20	1389.50±23.23	1868±16.59*	143.08±0.65	-	52.91±0.38	60.68 ±0.36*	115.63±2.00	264.89±3.32*
1997-1999										
HI	104	1266.99±11.71	1477.82±18.26	1547±24.21	127.50±1.03	47.91±0.23	54.64±0.29	53.26±0.66	120.82±1.88	223.94±4.51
1999-2001										
HI	104	1266.99±1.71	1477.82±18.26	1542 ±21.65	127.50±1.03	47.91±0.23	54.64±0.29	53.24±0.66	120.82±1.88	221.31±4.81
2001-02										
HI	77	1210.12±12.7	1413.88±18.44	-	133.51±1.22	54.33 ±0.53	57.40 ±0.41	-	97.62 ±2.98	-
2002-04										
HI	138	1252 ± 15.98**	1269 ±14.24	1616 ±24.42	137.0 ±1.32	52.63 ±0.29	55.18 ±0.29	63.50 ±0.40	64.41 ±8.12	183.72 ±5.51
S-29										
HI	233	1056	1578±13.49	1666±14.73	141.2±0.69	47.82±0.21	54.34±0.18	57.60±1.91	105	235
S-30										
HI	127	1001	1325	1464	146	46.21	52.19	53.91	86.69	201
S-31										
HI	179		1379	1526	139.23	47.93	51.42	56.31	99.70	178.41

*traits recorded upto 72 weeks of age　　**trait recorded at 16 wk of age

NB- The initial egg weight was recorder at the age of 28th wk instead of 32nd wk with effect from 1997

Genetic parameters over the generations

Heritability

Heritability was estimated for part period egg production at 40 weeks of age from S-20 to S-27. Sire component of heritability was showing an increasing trend from S-24 to S-27 generations for IWH line over the years while sire heritability seems to be on a downward trend for IWI line. Heritability based on dam component was also negative for IWI and IWC lines in the last generation. Interestingly, IWC population is also witnessing a decline in the heritability components over the generations (Table 51).

Table 51. Heritability estimates for parts period egg number (40-wk) in different lines over the generations

Gen.	IWH		IWI		IWC	
	h^2_S	h^2_D	h^2_S	h^2_D	h^2_S	h^2_D
S-20	-	0.56±0.34	0.35±0.18	0.15±0.17	-	-
S-21	0.05±0.05	0.19±0.08	0.18±0.06	0.01±0.07	0.20±0.15	0.32±0.21
S-22	0.11±0.05	0.17±0.08	0.15±0.07	0.05±0.09	-	-
S-23	0.12±0.06	0.001±0.09	0.13±0.06	0.07±0.08	0.54±0.22	0.31±0.19
S-24	0.02±0.03	0.24 ±0.07	0.13 ±0.05	0.09 ±0.06	0.25 ±0.14	0.52±0.19
S-25	0.02±0.03	0.24±0.07	0.13±0.05	0.09±0.06	0.25±0.14	0.52±0.19
S-26	0.09±0.10	-	0.02±0.08	-	0.17±0.11	0.15±0.15
S-27	0.17±0.08	0.06±0.10	0.09±0.50	-	0.067±0.07	-

Genetic correlation between egg production and other economic traits

The genetic correlation estimates from sire and dam components have been reported in Tables 52 and 53. For sire component, the genetic correlation between egg production up to 280 days and body weight at 20 and 40 weeks is generally negative for IWH line while for IWI line, it is positive for egg production with BW20 but negative with BW40 trait. Furthermore, as per the expectation, the genetic correlation between egg production and ASM was negative as early maturity leads to higher production performance. In S-27 generation, correlation with EW40 was highly positive for IWH line but moderately negative for IWI and IWC lines.

Table 52. Genetic correlation from sire component (rgS) between egg production and other economic traits of different White Leghorn strains since S-20 to S-27 generations

Gen.	Strain	BW 20 vs. BW16	EP 40 vs. BW 40	EP 40 vs. ASM	EP 40 vs. EW40
S-20	IWH	0.15±0.41	0.33±0.58	0.59±0.51	- 0.17±0.42
	IWI	0.72±0.36	0.26±0.56	-0.73±0.15	0.54±0.27
S-21	IWH	-0.24±0.36	-0.49±0.30	-0.55±0.34	0.21±0.41
	IWI	0.28±0.25	-0.03±0.26	-	-0.13±0.24
	IWC	0.59±0.35	-0.21±0.46	-0.71±0.18	-
S-22	IWH	-0.28±0.28	-0.27±0.26	-0.60±0.18	0.17±0.41
	IWI	0.40±0.27	0.08±0.27	-0.57±0.25	-0.23±0.25
S-23	IWH	-0.25±0.35	-0.16±0.51	-0.85±0.08	-0.34±0.28
	IWI	0.05±0.33	-0.26±0.38	-	-0.21±0.29
	IWC	0.42±0.21	0.32±0.29	-0.85± 0.08	-0.37±0.24
S-24	IWH	-0.01±0.43	-0.36±0.45	-0.12±0.63	0.07±0.40
	IWI	0.15±0.23	-0.09±0.23	-0.74±0.28	0.12±0.25
	IWC	0.75±0.21	0.43±0.26	-0.70±0.33	-0.94±0.22
S-25	IWH	0.04±0.32	-0.11±0.32	-0.14±0.44	0.15±0.32
	IWI	0.12±0.29	-0.28±0.28	0.11±0.55	0.11±0.33
	IWC	0.29±0.40	>1	0.30±0.49	-0.85±0.44

S-27	IWH	-0.51±0.72#	0.46±0.20	0.27±0.35	0.44±0.26
	IWI	0.15±.53#	-0.26±0.37	-0.39±0.30	-0.19±0.30
	IWC	0.32±0.44#	0.64±0.39	-0.76±0.17	-0.14±0.46

*Genetic correlation of 64 wk EP with other economic traits   # 16 wk body weight

Table 53. Genetic correlation from dam component (rGD) between egg production and other economic traits in different strains of White Leghorn over the generations

Gen.	Strain	BW 20 vs. BW16	EP 40 vs. BW 40	EP 40 vs. ASM	EP 40 vs. EW40
S-20	IWH	-0.75±0.48	-0.74±0.19	-0.89±0.19	-
	IWI	0.15±0.45	-0.01±0.45	-0.67±0.44	-0.36±0.56
S-21	IWH	-0.24±0.22	-0.08±0.22	-0.07±0.25	0.01±0.22
	IWI	-0.91±0.33	-	-0.51±1.33	-
	IWC	-0.04±0.48	-0.12±0.48	-0.97±0.02	-0.42±0.25
S-22	IWH	-0.39±0.22	-0.25±0.23	-0.11±0.23	-0.17±0.18
	IWI	-0.21±0.80	-	-0.81±0.29	0.26±0.56
S-23	IWH	-	0.96±0.17	-	-
	IWI	0.60±0.25	0.62±0.28	-	-
	IWC	> 1	0.93±0.06	-0.16±0.73	-0.26±0.42
S-24	IWH	-0.36±0.18	-0.21±0.19	-0.58±0.41	-0.25±0.21
	IWI	0.47±0.29	0.37±0.34	->1	0.22±0.28
	IWC	-0.09±0.35	0.21±0.65	-0.32±0.77	0.19±0.26
S-25	IWH	-0.41±0.37	-0.39±0.38	-0.93±0.77	-0.36±0.44
	IWI	0.25±0.23	0.54±0.26	-0.31±0.29	0.08±0.22
	IWC	-0.36±0.36	-0.64±0.55	-0.34±0.55	0.26±0.26
S-27	IWH	-0.11±0.59#	-0.54±0.43	>1	-0.26±0.41
	IWI	0.48±0.08#	0.52±0.41	<-1	0.11±0.27
	IWC	0.14±0.26#	-0.03±0.31	-0.24±0.29	0.10±0.35

*Genetic correlation of 64 wk EP with other economic traits   # 16 wk body weight

Random Sample Poultry Performance Test

The performance of the strain cross of CARI has been presented in Tables 54 and 55 and it is observed that after 1986–87, the strain cross ranked first many a times in different centres. The average egg weight was also optimum.

Table 54. Year wise performance of C.A.R.I. layer at various random sample laying test conducted by Govt. of India (R.S.P.P.T.) and project testing centres

Year of testing	Centre	Entry specification of CARI Centre	HDEP (Nos)	HHEP (Nos)	Avg. EWT (g)	Return (Rs)	Rank/ Position
1	2	4	5	6	7	8	9
1978-79	Bangalore	HG	242.9	256.8	53.5	31.90	
	Bombay	HG	220.8	238.9	53.0	24.29	
	Bangalore	HI	227.7	239.4	54.8	27.43	
	Bombay	HI	220.8	249.1	53.5	27.05	
1979-80	Bangalore	HG	241.8	251.2	53.3	37.81	
	Bombay	HG	249.4	260.2	49.9	30.53	
	Bhubaneswar	HG	218.1	238.7	52.0	31.77	
	Bangalore	HI	245.8	261.4	56.1	39.85	
	Bombay	HI	250.8	262.4	49.6	19.74	
	Bhubaneswar	HI	238.8	247.9	51.7	37.03	
	Bangalore	JG	255.1	263.9	51.5	39.25	
	Bombay	JG	222.3	259.9	50.8	11.71	
	Bhubaneswar	JG	192.8	224.9	51.1	20.59	
	Anand	HG	199.0	240	52.3	-	
	Anand	HI	218.0	216.0	53.8	-	
	Anand	JG	175.0	237.0	52.5	-	
1980-81	Bangalore	HG	250.4	262.6	54.5	45.89	
	Bhubaneswar	HG	224.2	233.1	50.8	39.53	
	Bangalore	HI	260.6	265.0	55.0	47.76	
	Bombay	HI	247.9	256.3	50.9	30.55	
	Bhubaneswar	HI	230.9	232.6	52.2	42.99	
	Bangalore	JG	246.8	252.6	56.0	44.10	
	Bombay	JG	248.1	253.3	50.1	29.76	
	Bhubaneswar	JG	195.0	203.5	52.2	28.34	
	Anand	HG	206.8	220.2	52.2	19.26	
	Anand	HI	215.4	232.4	53.8	21.51	
	Anand	JG	182.3	205.8	51.6	10.88	
1981-82	Bombay	HG	240.5	253.5	50.2	34.49	
	Bangalore	HI	262.1	274.4	50.3	37.76	
	Bombay	HI	244.7	255.3	49.6	36.54	
	Bangalore	JG	256.4	264.4	51.6	32.21	
	Bombay	JG	222.5	241.0	50.8	27.41	
	Anand	HG	222.7	236.5	53.7	21.18	
	Anand	HI	238.3	247.6	53.2	15.97	
	Anand	JG	209.4	233.8	50.3	13.20	

Year of testing	Centre	Entry specification of CARI Centre	HDEP (Nos)	HHEP (Nos)	Avg. EWT (g)	Return (Rs)	Rank/ Position
1982-83	Bangalore	HG	250.6	263.9	52.9	10.52*	
	Bhubaneswar	HG	226.5	235.2	51.6	47.85	
	Bangalore	HI	260.3	267.4	52.8	14.14*	
	Bhubaneswar	HI	246.6	247.5	53.4	55.39	
	Bhubaneswar	JG	222.5	228.8	52.1	46.55	
1985-86	Bangalore	HG	230.4	246.5	53.5	33.41	
	Anand	HG	214.0	234.0	51.6	37.49	
	Bangalore	B/C	217.5	237.1	53.1	23.37	
	Bangalore	S/C	246.5	230.4	53.5	33.40	4th
	Anand	S/C	234.7	220.8	51.7	42.97	1st
1986-87	Bangalore	HI	248.0	254.0	51.3	16.07*	
	Anand	HI	223.09	239.4	50.23	26.79	
	Bhubaneswar	B/C	25.4	261.3	51.3	19.30	
	Bangalore	Br/C	261.3	255.4	51.3	29.30	1st
	Anand	S/C	234.0	214.0	51.6	37.49	1st
1988-89	Bhubaneswar	B/C	248.0	262.2	49.0	42.95	
1989-90	Anand	S/C	243.4	235.2	54.4	40.80	-
	Anand	HI	235.2	243.4	54.4	40.80	
	Anand	HG	224.4	234.2	51.4	29.43	
1991-92	Bangalore	S/C	270.2	256.5	52.9	51.56	1st
1992-93	Bombay	S/C	239.1	219.8	54.2	-	1st
	Bhubaneshwar	S/C	243.5	234.0	49.2	28.93	2nd
		S/C	255.0	246.0	49.0	24.36	3rd
1993-94	Gurgaon	S/C	262.9	254.1	54.2	31.87	1st
		B/C	266.5	220.0	53.4	-	4th
	Bombay	Cross-1	270.9	253.1	52.9	56.15	2nd
		Cross-2	254.2	234.3	48.9	38.92	4th
1994-95	Bhubaneshwar	S/C	263.8	251.3	51.8	38.54	1st
1995-96	Bhubaneshwar	S/C	259.8	253.1	53.1	6.71	1st

Table 55. Year wise performance of C.A.R.I. layer at various random sample laying test conducted by govt. of India (R.S.P.P.T.) and project testing centres

Year of testing/ Centre	Name of the Centre Participated	Entry specification of CARI Centre	HDEP (nos.)	HHEP (nos.)	Avg. EWT (gm)	F/ doz.	F/ Kg.	Return (rs)	Rank/ Position
1	2	3	4	5	6	7	8	9	10
1996-97 Gurgaon	CARI, Izatnagar		278.00	252.30	53.53	1.92		47.97	2nd
1997-98 Bombay	CARI, Izatnagar	S/C	246.60	244.57	51.27	1.74	3.18	51.50	3rd
1997-98 Gurgaon	CARI, Izatnagar	S/C	262.6	252.5	51.3			42.36	1st
1997-98 Bhuba-neshwar	CARI, Izatnagar	S/C	252.8	229.9	54.9			-	2nd
1998-99 GAU Anand	CARI, Izatnagar	S/C	270.3	267.8	-			-	1st
1998-99 Bangalore	CARI, Izatnagar	S/C	274.85	262.74	56.03 dl 57.68 cage			23.84	3rd
1998-99 Bhuba-neshwar	CARI, Izatnagar	B/C	283.06	280.88	52.7			-	2nd
1999-00 Hesaraghatta Cage	CARI, Izatnagar	S/C	271.42	264.93	58.37		2.01	33.45	5th
Deep litter	CARI, Izatnagar	S/C	276.01	266.45	57.20		2.13	16.2	6th
2000-01 Bangalore	CARI (Cage)	S/C	301.79	298.38	57.41		1.77	58.29	1st
	CARI (Deep litter)	S/C	289.07	281.46	54.17		2.12	3.24	1st
2001-02 Bhuba-neshwar	CARI Izatnagar	S/C	270.99	262.24	54.35	1.93	3.08	-	3rd
	CARI Izatnagar	B/C	267.78	261.93	54.03	2.09	3.11	-	4th
2002-03 Bangalore	Cage House	HI	289.12	287.83	54.63	1.94	2.96	-	3rd
	Deep Litter	JG X HI	300.96	300.96	53.55	2.00	3.11	-	2nd
		HI	285.02	284.55	54.12	2.08	3.2	-	4th

5 Karnataka Veterinary Animal and Fishery Sciences University, Bengaluru

The two important research programs funded by Indian Council of Agricultural Research *viz. Improvement of poultry through family selection* and *Diallel crossing for broiler production* operated during the years 1962-65 and 1968-71 respectively for improving egg and meat type birds available in the country. The two programs were merged with AICRP on Poultry Breeding which started during IV plan (1970) to produce superior genetic stocks of layer and broiler and thereby, to achieve self-sufficiency. AICRP on Poultry Breeding for meat came into existence at Bangalore w.e.f. 14-01-1970. A separate control unit was set up on 01-04-1981.

Achievements

At Bangalore centre, "*Diallel crossing for Broiler Production*" operated during the years from 1968-71. The breeds utilized in this project were White Cornish (WC), New Hampshire (NH), White Rocks (WR) and Australorp (AL). These four breeds were crossed in a full 4x4 Diallel crossing. Both WC and WR were equally good when utilized as male parent line for improvement of ten weeks body weight. On the other hand, NH and WC were good when used as female parent lines. AL was poorest in performance whether used as male or female line. Feed efficiency (0-10 weeks) was almost equal in all the genetic groups. Survivability up to 10 weeks of age was generally high. Breast angle at 10 weeks of age was comparatively wider in WC and WR groups than in AL and NH groups. Shank length was comparatively shorter in the AL and NH groups than in WC and WR groups. Dressed weight at 10 weeks of age was similar in all the genetic groups. Hatchability on fertile eggs set was higher in the WR and AL groups than in WC and NH groups. The mean squares from ANOVA for combining ability effects for each of the sexes indicated that body weight at 10 weeks of age was not significantly different in any of the parental lines used as male or female lines.

Selection records

Generation wise effective population size (Ne), selection differentials for early body weight (SD), selection intensity (i) and rate of inbreeding (ΔF) per generation for IC3 and IR3 strains are furnished in Table 56.

In IC.3 strain, Ne, SD, I and ΔF ranged from 132 (1991) to 338 (1983), from 72 (1981) to 181 g (1984), from 0.21 (1990) to 1.41 (1992) and from 0.001 (1989) to 0.004 (1981, 1987, 1991) respectively. In IR.3 strain, the corresponding figures ranged from 138 (1991) to 343 (1989), from 72 (1978) to 198g (1997), from 0.21 (1989) to 1.83 (1992) and from 0.002 (1980, 1982-83, 1985-90) to 0.004 (1981, 1991) respectively.

Performance of the traits

The fertility and hatchability rates were not significant between the strains: There was a non-significant change in both fertility and hatchability to the extent of -0.29 ± 0.16 and -0.23 ± 0.16 in IC3, -0.22 ± 0.17 and -0.56 ± 0.17 in IR3 strain, respectively (Table 57). Six-week body weight of both the selected strains showed a non-significant decrease in body weight to the extent of 24.63 ± 17.74 and 15.17 ± 11.95g in IC3 and IR3 strains, respectively (Table 58). Both the strains showed a non-significant response of -0.05 ± 0.04 and 0.02 ± 0.03 in feed efficiency. Six week dressed weight also showed a non-significant change of -0.01 ± 0.23 and 0.30 ± 0.32 in IC.3 and IR3 strains, respectively (Table 59). Mean survivability during brooding, growing and laying phases did not show any significant change in either of the strains (Table 60). Age at sexual maturity showed non-significant decrease of -0.01 ± 0.47 in IC3 and -0.22 ± 0.71 days in IR3 strains (Table 61). The average response in egg production up to 280 days of age was -0.37 ± 0.31 in IC3 and 0.31 ± 0.43 eggs in IR3 strains. Both the estimates were not significant (Table 62). The increase in body weight at first egg was meagre and non-significant, the values being 11.21 ± 5.26 and 7.29 ± 5.65 in IC3 and IR3 strains, respectively (Table 63).

The average response per generation to selection was calculated as the regression of mean body weight on generation number. From 1973 to 1985, eight-week body weight was the primary trait of selection and subsequently, six-week body weight. Records were maintained on 8-week body weight, feed efficiency, survivability, age at sexual maturity, body weight at sexual maturity, egg production up to 280 days of age, fertility and hatchability of fertile eggs.

Table 56. Summary of selection records over different years for IC3 and IR3 strains

Strain	Parameter	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
IC3	Ne	220	136	279	338	250	267	221	235	249	311	134	132	148
	SD (g)	132	72	146	126	181	147	145	175	118	90	101	160	128
	i	0.90	0.43	1.00	0.90	0.87	0.87	0.46	0.56	0.39	0.24	0.21	0.54	1.41
	ΔF	0.002	0.004	0.002	0.002	0.002	0.002	0.002	0.004	0.002	0.001	0.002	0.004	0.003
IR3	Ne	222	142	264	284	253	267	207	224	220	343	154	138	153
	SD (g)	153	73	165	128	153	146	125	198	95	80	100	137	112
	i	1.01	0.49	1.04	0.92	0.70	0.82	0.38	0.46	0.32	0.21	0.22	0.30	1.83
	ΔF	0.002	0.004	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.004	0.003

Table 57. Progress in IC3 and IR3 strains for fertility and hatchability on fertile eggs set

Strain	Parameter	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Response	SE
IC3	Fertility (%)	89.41	93.58	87.99	91.17	91.17	92.13	86.27	87.99	89.87	84.32	79.95	82.10	88.27	-0.29	0.16
	Hatchability (%)	81.68	87.43	85.36	88.33	80.80	90.29	86.29	85.91	87.10	83.69	80.28	84.40	73.47	-0.23	0.16
IR3	Fertility (%)	93.48	92.20	91.75	92.38	92.88	93.99	90.30	92.82	92.51	89.17	83.33	85.50	90.47	-0.22	0.17
	Hatchability (%)	84.76	88.61	87.11	88.59	88.59	87.44	84.78	85.03	89.14	85.48	82.44	81.00	77.94	-0.56	0.17

Table 58. Progress for body weight (g) at 6/8 weeks of age in IC3 and IR3 strains

Strain	Parameter	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Response
IC3	N	1861	1798	2100	2069	707	1958	833	1079	1615	1459	1868	2151	2314	-
	X	1256.21	1095.27	1006.5	1381.03	1363.36	1475.97	1589.50	937.52	968.14	964.23	963.60	786.12	874.44	-24.63
	SE	3.40	3.98	3.19	3.07	10.40	4.39	11.37	5.35	7.55	8.10	8.90	3.00	3.09	17.74
	CV (%)	11.64	15.41	14.48	10.14	20.28	13.16	20.64	18.67	31.34	32.09	39.92	17.70	16.51	-
IR3	N	2240	2530	2452	2718	1282	2541	1028	1675	2668	2441	3177	2400	2708	
	X	1181.07	1072.50	1040.50	1272.15	1264.18	1390.46	1572.56	915.46	940.65	936.48	953.40	829.04	872.63	-15.17
	SE	3.21	3.22	3.22	2.69	8.38	3.83	10.16	4.84	5.74	6.48	8.22	2.30	2.31	11.95
	CV (%)	12.91	15.09	15.25	11.01	23.73	13.88	20.71	21.64	31.52	34.19	30.86	13.59	13.72	-

Table 59. Progress in IC3 and IR3 strains for feed efficiency (FE) at 8/6 weeks of age and dressed weight (DW)

Strain	Parameter	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Response	SE
IC3	FE	2.63	2.98	2.81	2.68	2.65	2.46	2.22	2.47	2.08	2.45	2.28	2.11	2.11	-0.05	0.04
	DW	71.61	72.63	72.53	72.53	71.25	74.55	73.76	72.11	73.74	74.15	73.79	72.18	73.04	-0.01	0.23
IR3	FE	2.36	2.84	2.78	2.63	2.82	2.42	2.33	2.01	2.03	2.23	2.22	2.06	2.13	0.02	0.03
	DW	72.75	73.00	70.10	72.13	70.82	73.87	73.20	70.65	72.86	73.61	73.48	73.98	72.14	0.30	0.32

Table 60. Progress in IC3 and IR3 strains for survivability

Strain	Survivability (%)	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Response	SE
IC3	Brooder	96.63	97.47	96.69	98.64	88.37	98.74	99.12	98.69	98.03	98.57	98.52	98.20	95.60	-0.43	0.28
	Grower	96.00	96.95	96.31	99.51	98.85	97.43	99.05	97.85	97.83	97.28	96.43	97.10	96.89	-0.22	0.12
	Layer	97.79	98.72	98.24	98.65	97.15	96.90	98.98	96.95	96.00	96.53	96.21	97.00	97.12	0.10	0.12
IR3	Brooder	98.12	99.14	98.59	97.95	87.46	97.81	97.18	99.07	97.64	98.49	98.45	97.90	97.69	-0.17	0.14
	Grower	96.88	96.76	95.96	99.26	99.12	98.89	98.09	98.08	98.43	97.89	97.92	96.40	97.12	-0.31	0.16
	Layer	97.87	99.32	99.20	96.67	97.83	97.84	99.00	98.85	90.49	95.45	96.52	96.40	97.89	0.40	0.78

Table 61. Progress in IC3 and IR3 strains for age at first egg (days)

Strain	Parameter	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Response
IC3	N	305	312	325	394	176	219	196	317	225	289	324	206	159	-
	X	184.50	136.75	194.00	199.84	171.00	181.00	186.39	189.12	174.58	194.63	214.12	186	187	-0.0069
	SE	1.15	1.02	1.04	0.73	1.26	0.96	1.28	0.62	0.84	1.34	2.28	1.00	1.53	0.4669
	CV (%)	10.82	9.66	9.61	9.15	9.78	7.85	9.61	5.84	7.22	11.70	19.16	7.72	10.32	
IR3	N	353	311	373	390	185	317	302	352	326	498	436	279	230	
	X	176.45	182.50	185.00	171.22	160.63	167.40	174.85	180.39	163.20	190.69	210.89	182	180	-0.2189
	SE	0.82	1.06	1.96	0.51	0.94	0.98	1.12	0.80	0.55	0.84	0.98	0.90	1.16	0.7054
	CV (%)	8.75	10.22	10.02	5.87	7.96	10.42	11.13	8.32	6.08	9.83	9.70	8.26	9.77	

Table 62. Progress in IC3 and IR3 strains for egg production up to 280 days of age

Strain	Parameter	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Response
IC3	N	291	303	298	249	171	219	194	306	216	289	318	200	159	-
	X	57.00	51.50	44.00	52.36	51.05	50.89	45.75	49.48	59.08	39.45	38.41	38.00	38.00	-0.3729
	SE	0.77	0.71	0.83	0.91	1.11	1.01	1.10	0.61	0.57	0.87	0.87	0.60	0.80	0.3206
	CV (%)	23.40	23.84	32.50	29.35	14.52	29.37	33.49	21.56	14.18	37.49	40.39	22.33	26.55	
IR3	N	333	297	367	301	176	317	299	336	295	498	421	269	230	
	X	65.00	63.00	60.00	71.22	71.46	73.54	63.92	71.60	72.76	52.69	55.15	57.00	58.00	0.3107
	SE	1.09	0.81	0.93	0.71	0.82	0.89	1.00	0.80	0.58	0.66	0.59	0.70	0.77	0.429
	CV (%)	30.64	22.23	29.56	18.22	15.22	21.55	27.05	20.48	13.69	27.95	21.95	20.14	20.13	

Table 63. Progress in IC3 and IR4 strains for body weight (g) at age at first egg

Strain	Parameter	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Response
IC3	N	305	312	325	294	176	219	296	317	225	289	324	306	159	-
	X	3083	3222	3220	3387	3070	3230	3210	3210	3180	3460	3010	3210	3120	11.2128
	SE	15.46	18.07	11.67	17.35	20.00	20.00	10.00	10.00	10.00	10.00	10.00	20.00	20.00	5.2563
	CV (%)	8.31	9.90	6.54	8.78	8.64	9.16	4.36	5.55	4.72	4.91	5.98	8.94	8.08	
IR3	N	353	311	373	390	185	317	302	352	326	498	436	279	230	
	X	3082	3044	2871	2862	2850	3040	3060	3080	3000	3310	2890	3100	2990	7.2859
	SE	12.86	16.01	9.56	10.40	20.00	20.00	10.00	7.00	20.00	10.00	20.00	10.00	9.00	5.6499
	CV (%)	7.46	9.28	6.43	7.17	9.54	11.71	5.68	4.26	12.04	6.74	14.45	5.40	4.56	

Genetic Parameters

Heritability

The heritability estimates were obtained on raw data for body weight at 8 weeks of age (up to 1985-86) and on 6-week body weight subsequently. The full sib method was followed for the combined sexes when early body weight was recorded at 6 and 8 weeks of age. Half-sib analysis was followed for egg production and allied traits recorded in the selected pullets.

The heritability estimates on 8-week body weight and also of 6-week body weight (1986 onwards) are presented in Table 64. The pooled h^2 estimate up to the end of 1993 was 0.29±0.04, 0.07±0.02 and 0.14±0.02 in the IC3 strain from the sire, dam and sire + dam components, respectively. The corresponding estimates from the different components in the IR3 strains were 0.18±0.02, 0.19±0.02 and 0.17±0.05, respectively. These estimates suggested low additive genetic variance in both the strains. While sex-linked variance was involved in the IC3 strain, maternal variance was important in the IR3 strain.

The h^2 estimates of ASM, body weight at sexual maturity, and body weight at 8/6 weeks of age as well as egg production are detailed in Table 65. The pooled estimates of these traits (from the year 1975-1992) were 0.29±0.14, 0.24±0.13, 0.18±0.12 and 0.20±0.13 in the IC3 strain, 0.53 ± 0.17, 0.43 ± 0.16, 0.27 ± 0.14, 0.38 ± 0.16 in the IR3 strain, respectively.

Correlation

Body weight (8/6) and egg production: The genetic correlation between BW6 and EP fluctuated over the years in both the strains. They were generally positive in IC3 ranging from 0.08 ± 0.12 (1986) to 0.71 ± 0.20 (1984). In IR3 strain, generally negative estimates ranging from –0.001 ± 0.10 (1982) to < -1 (1979,1984) was obtained. The environmental correlation in the IC3 strain ranged from 0.02 (1978) < -1. In the IR3 strain, positive environmental correlations ranging from 0.02 (1978) to 0.76 (1986) were estimated. The phenotypic correlations ranged from –0.01 ± 0.07 (1979) to 0.31 ± 0.04 (1992) in the IC3 strain. In the IR3 strain, the range was from –0.01 ± 0.03 (1991) to 0.62 ± 0.04 (1992).

In the IC3 strain, both 6-week body weight and body weight at sexual maturity were positively related genetically and phenotypically. The genetic correlations ranged from 0.29 ± 0.10 (1987) to 0.49 ± 0.16 (1991), while the phenotypic correlations ranged from 0.19 ±0.09 (1990) to 0.38 ± 0.12 (1986). The environmental correlations were generally positive.

Positive genotypic and phenotypic correlations existed in both the strains between six weeks body weight and Age at Sexual maturity. In IC3 strain, the genetic correlations ranged from 0.18 ± 0.04 (1987) to 0.42 ± 0.56 (1986), whereas the phenotypic correlations were of the range 0.09 ± 0.06 (1987) to 0.02 ± 0.12 (1992). Fluctuating environmental correlations existed. In IR3 strain, the positive genetic correlations ranged from 0.39 ± 0.22 (1990) to 0.73 ± 0.36 (1991), while the phenotypic correlations were from 0.06 ± 0.04 (1992) to 0.18 ± 0.12 (19987). The fluctuating environmental correlations ranged from –0.07 (1986) to v 0.18 (1988).

Negative genetic, environmental and phenotypic correlations existed between body weight at sexual maturity and egg production in both IC3 and IR3 strains over the generations. Pullets, which were heavy at maturity, laid fewer eggs. Egg production and age at sexual maturity had negative genetic, environmental and phenotypic correlations in both IC3 and IR3 strains, implied that early maturing pullets laid more number of eggs over the years. Most of the phenotypic correlations were significant. In both the strains, from 1986 to 1990, both body weight and age at sexual maturity were positively related on genetic, environmental and phenotypic backgrounds. Phenotypic correlations were significant in general implying that pullets heavy at sexual maturity matured late.

Genetic gains and correlated responses

Direct selection for body weight at six weeks of age resulted in maximum improvement of 61.36g in IC3 and 78.88g in IR3 strain during 1992 (Table 66).

The correlated response in ASM (days) body weight at sexual maturity (g) and egg production (no) during

1992 were 0.52, 6.78 and 0.08 respectively in IC3 and 0.42, 4.12 and 0.84 respectively in IR3 strain during 1992. In IC3 strain, the correlated response ranged from 0.24 (1990) to 0.72 d. (1986) for ASM, from 4.64 (1986) to 16.77g (1987) for body weight at sexual maturity, and from –0.32 (1987) to 0.08 eggs (1992) for EP. These figures in IR3 strain were, from –2.47 (1987) to 0.78 days (1986) for ASM, from –6.51 (1986) to 5.29 g (1987) for body weight at sexual maturity and from –0.01 (1988) to 2.28 (1987) eggs.

Table 64. Heritability estimates and standard errors for 8-week body weight for IC3 and IR3 strains

Strain	Parameter	1988	1989	1990	1991	1992	Pooled
IC3	S	0.46 ± 0.10	0.28 ± 0.13	0.29 ± 0.12	0.31 ± 0.05	0.30 ± 0.07	0.29 ± 0.04
	D	-	-	-	0.15± 0.08	-	0.07 ± 0.02
	S+D	-	--	-	0.20 ± 0.07	-	0.14 ± 0.02
IR3	S	0.31 ± 0.08	0.30 ± 0.11	0.11 ± 0.03	0.29 ± 0.06	0.33 ± 0.07	0.18 ± 0.02
	D	0.42 ± 0.10	0.31± 0.10	0.23 ± 0.12	0.18 ± 0.10	-	0.19 ± 0.02
	S+D	0.36 ± 0.08	0.31 ± 0.07	0.18 ± 0.04	0.17 ± 0.06	-	0.17 ± 0.05

Table 65. Heritability estimates and standard errors for egg production and allied traits in IC3 and IR3 strains (Paternal half-sib analysis)

Strain	Traits	1987	1988	1989	1990	1991	1992
IC3	ASM	0.24 ± 0.18	0.18 ± 0.09	0.21 ± 0.15	0.12 ± 0.09	0.41 ± 0.21	0.29 ± 0.14
	BWSM	0.21 ± 0.06	0.24 ± 0.12	0.18 ± 0.09	-ve-	0.23 ± 0.18	0.24 ± 0.13
	BW8	0.18 ± 0.12	-ve-	0.24 ± 0.18	0.14 ± 0.11	0.45 ± 0.26	0.18 ± 0.12
	EP	0.09 ± 0.07	-ve-	-ve-	-ve-	0.01 ± 0.15	0.20 ± 0.13
IR3	ASM	0.31 ± 0.19	0.31 ± 0.12	0.38 ± 0.16	0.24 ± 0.16	0.12 ± 0.14	0.53 ± 0.17
	BWSM	0.28 ± 0.14	0.18 ± 0.04	0.21 ± 0.12	0.23 ± 0.08	0.57± 0.21	0.43 ± 0.16
	BW8	0.14 ± 0.10	0.12 ± 0.09	0.08 ± 0.14	0.18 ± 0.12	0.43 ± 0.27	0.27 ± 0.14
	EP	0.31 ± 0.21	0.30 ± 0.12	0.12 ± 0.09	0.07 ± 0.02	0.23 ± 0.16	0.38 ± 0.16

Table 66. Genetic gain in eight weeks body weight and correlated responses in IC3 and IR3 strains

Strain	Traits	1987	1988	1989	1990	1991	1992
IC3	BW8 (g)	17.82	19.25	29.20	19.20	52.12	61.36
	ASM (days)	0.41	*	0.32	0.24	0.48	0.52
	BW at sexual maturity (g)	16.77	*	3.18	*	8.17	6.78
	EP (Nos)	-0.32	*	*	*	0.06	0.08
IR3	BW8 (g)	12.61	37.62	18.49	18.00	23.24	77.88
	ASM (days)	-2.47	0.60	0.24	0.18	0.31	0.42
	BW at sexual maturity (g)	5.29	0.07	1.23	1.12	3.13	4.12
	EP (no.)	2.28	-0.01	0.18	0.16	0.93	0.84

PB-1 and PB-2 synthetic broiler strains were introduced from 1993 onwards at the centre. The achievements of these lines are detailed below.

Selection records

The generation-wise effective population size (Ne), selection differentials for early body weight (SD), selection intensity (i) and rate of inbreeding (ΔF) per generation for PB-1 and PB-2 lines are furnished in Tables 67 and 68, respectively. A decreasing trend is witnessed in the selection differential as well as selection intensity, the probable reason being the increased homozygosity of the population as a response to selection, thereby, reducing the variation.

Incubation records

The generation wise fertility, hatchability on TES and FES for PB-1, PB-2 and Control lines are presented in Tables 69, 70 and 71, respectively.

In PB-1 strain, the average fertility, hatchability based on TES and FES over the generations was 88.02, 76.79 and 87.66% respectively. The corresponding figures for PB-2 strain were 81.85, 69.30 and 84.34% respectively. In the control line, the values for the concerned traits varied were 81.88, 70.42 and 85.06%, respectively. Substantial improvement in fertility as well as hatchability has been observed over the generations in all the strains.

Mortality records

Generation wise mortality for various duration *viz.*, from 0 to 8, from 9 to 16, from 17 to 40, 41 to 64 and 17 to 64 weeks of age for strains PB-1, PB-2 and control lines are summarized in Table 72. The data revealed that the mortality recorded during different periods was well within the range specified. Also, a decreasing trend is observed in mortality over generations and PB-2 line had comparatively lesser mortality during the period from 0 to 8 weeks and 9 to 16 weeks compared to PB-1 suggesting comparatively better resistance in PB-2 birds.

Performance of broiler traits

The generation wise performance of PB-1, PB-2 and Control lines for broiler traits *viz.,* body weight at day old, body weight at 5/6 weeks of age, feed efficiency up to 5/6 weeks of age over the past few generations is presented in Table 73. In PB-1, day old body weight ranged from 39.86 (S-9) to 44.25 (S-8) whereas in PB-2, it ranged from 40.08 (S-22) to 44.10 (S-21) and in control line from 39.11 (S-25) to 42.32 (S-18). In PB-1 strain, average body weight at five weeks ranged from 956.2 g (S-14) to 1260 g (S-10). In PB-2 strain, the average body weight recorded at 5 weeks of age ranged from 947.2 g (S-27) to 1171 g (S-21). The corresponding values for the control line varied from 562.4 g (S-23) to 1008 g (S-18). The FCR has been maintained between 2.07 to 2.21 in different generations of PB-1 strain. In PB-2 strain, the corresponding values were 2.03 to 2.38 while it was 2.08 to 3.98 in control line due to absence of selection in the latter.

Table 67. Trend of selection records for PB-1 over the generations

Particulars	S-0	S-1	S-2	S-3	S4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	S-13	S1-4	S-15
No. of sires used	60	31	32	60	51	64	70	62	64	64	64	32	32	32	32	24
No. of dams used	246	223	256	480	408	512	560	512	509	512	512	254	256	256	240	186
No. of sires contributed	59	31	30	58	42	64	70	62	55	58	44	32	32	32	31	24
No. of dams contributed	162	23	240	464	336	487	500	506	439	507	352	254	251	244	232	186
Effective no. (Ne)	195.49	108	106.66	206.22	181.33	341.33	356.69	317.69	264.4	227	228	114	116	108	113	85
Rate of inbreeding (ΔF)	0.003	0.05	0.0037	0.0024	0.0027	0.0015	0.0014	0.0015	0.001	0.002	0.0022	0.0043	0.0039	0.0036	0.001	0.006
Average selection differential (SD)	-	-	-	246.25	83.94	129	125	103.48	104.12	176	121	87	94	88	76	86.4
Selection Intensity (i)	-	-	-	1.87	0.91	0.59	1.11	1.77	1.52	1.54	1.34	0.55	0.45	0.47	0.51	0.56

Table 68. Trend of selection records for PB-2 over the generations

Particulars	S-15	S-16	S-17	S-18	S-19	S-20	S-21	S-22	S-23	S-24	S-25	S-26	S-27	S-28
No. of sires used	70	70	70	60	87	90	58	58	57	20	16	14	31	23
No. of dams used	560	560	560	480	696	720	449	464	451	158	128	126	224	183
No. of sires contributed	68	70	70	60	79	83	56	58	35	20	16	14	31	23
No. of dams contributed	544	556	560	471	669	643	433	457	280	158	128	119	224	183
Effective no. (Ne)	241.77	248.69	248.88	213.33	405.37	424.41	251.23	210	202	71	70	59	62	81
Rate of inbreeding (ΔF)	0.0008	0.0020	0.0020	0.0023	0.00123	0.0011	0.008	0.0024	0.0023	0.0056	0.0057	0.0092	0.002	0.006
Avg. selection differential. (SD)	83.12	136.97	136.15	156	140	72.49	91.18	158	131	71	83	71	66	112.2
Avg. effective selection differential	82.14	49.86	-	146.50	-	-	164.18	184	138	-	-	-	-	-
Selection intensity (i)	1.38	0.97	1.63	1.05	1.2	1.78	1.64	1.48	1.26	0.47	0.41	0.39	0.44	0.63

Table 69. Trend of incubation and hatching results for PB-1

Gen.	TES (Nos.)	Fertility (%)	Good chicks (Nos.)	HTES (%)	HFES (%)
S-0	800	78.75	536	68.13	86.51
S-1	1406	84.35	962	70.98	84.14
S-2	2869	91.22	-	78.08	85.59
S-3	3700	90.35	2754	77.00	85.22
S-4	5292	89.51	4007	79.24	89.09
S-5	4499	88.87	3385	78.29	88.10
S-6	5526	88.27	4060	75.28	85.28
S-7	5321	89.04	4014	77.75	87.32
S-8	4326	88.37	3214	77.30	87.47
S-9	3925	91.34	3161	83.03	90.91
S-10	2243	89.34	1730	79.80	89.32
S-11	2391	89.21	1851	79.72	89.36
S-12	1850	88.65	1420	78.81	88.90
S-13	1831	88.80	1378	77.28	90.07
S-14	1332	83.71	920	71.17	85.02
S-15	675	88.59	530	80.00	90.30

Table 70. Trend of incubation and hatching results for PB-2

Gen.	TES (Nos.)	Fertility (%)	Good chicks	HTES (%)	HFES (%)
S-0	4089	69.72	539	38.73	55.56
S-1	6655	66.31	3157	50.37	75.96
S-2	8229	76.10	3928	62.17	81.69
S-3	7749	81.25	5097	69.34	85.34
S-4	12852	77.32	7945	68.70	88.86
S-5	4451	88.16	2148	77.87	91.86
S-6	11263	64.25	6016	54.39	84.65
S-7	10505	89.16	8361	80.85	90.63
S-8	5904	89.88	4671	80.44	89.50
S-9	10577	88.57	8121	78.69	88.85
S-10	10440	88.56	7778	77.39	87.39
S-11	10300	88.07	7594	76.41	86.76
S-12	11373	88.67	8798	78.32	88.33
S-13	10452	87.11	7450	74.16	85.13
S-14	8937	84.70	6287	71.72	84.67
S-15	9854	88.82	-	75.31	84.71
S-15	9854	88.82	-	75.31	84.71
S-16	9648	87.74	7100	75.34	85.87
S-17	10046	89.51	7924	80.52	90.24
S-18	8455	88.76	6471	78.35	88.28
S-19	4933	88.63	3732	77.34	87.26
S-20	3841	83.23	2008	54.62	65.55
S-21	4098	89.29	3134	78.43	87.84

Gen.	TES (Nos.)	Fertility (%)	Good chicks	HTES (%)	HFES (%)
S-22	2569	88.98	1953	77.85	87.49
S-23	1353	88.03	1010	77.16	87.66
S-24	663	88.24	500	76.92	87.18
S-25	961	84.18	705	74.30	88.26
S-26	843	90.15	642	77.70	86.18
S-27	1207	86.33	850	71.91	83.30
S-28	568	84.33	403	82.89	86.43

Table 71. Trend of incubation and hatching results for control line since inception

Gen	TES (Nos.)	Fertility (%)	Good chicks (Nos.)	HTES (%)	HFES (%)
S-1	546	78.75	238	46.15	58.61
S-2	482	81.33	334	71.58	88.01
S-3	488	90.16	380	79.30	87.96
S-4	576	75.00	462	80.38	91.86
S-5	597	78.22	347	58.29	74.52
S-6	401	91.52	326	82.79	90.46
S-7	505	81.78	358	71.68	87.65
S-8	500	86.80	393	78.80	90.78
S-9	407	91.40	331	83.53	91.39
S-10	417	83.45	317	76.50	91.67
S-11	732	90.98	604	84.56	92.94
S-12	626	88.44	499	82.27	93.30
S-13	415	85.54	305	74.70	87.32
S-14	318	65.09	154	49.05	75.36
S-15	397	81.61	-	64.08	79.01
S-16	409	76.06	262	65.02	85.51
S-17	400	88.75	275	76.75	86.48
S-18	851	88.64	633	77.23	87.13
S-19	420	88.10	323	78.10	88.65
S-20	208	81.73	103	51.92	63.53
S-21	185	84.86	129	71.39	84.08
S-22	210	57.14	94	45.71	80.00
S-23	202	79.20	127	65.35	82.5
S-24	210	83.81	150	72.85	86.93
S-25	189	66.14	113	60.84	92.00
S-28	208	84.50	169	82.21	93.95

Table 72. Mortality records for PB-1, PB-2 and control over the generations

PB-1				PB-2				Control			
Gen.	0-5 wks	6-16 wks	17-40 wks	Gen.	0-5 wks	6-16 wks	17-40 wks	Gen.	0-5 wks	6-16 wks	17-40 wks
S-0	3.25	4.40	17.39	S-10	3.60	0.40	4.56	S-10	2.50	1.80	4.56
S-1	1.40	-	10.14	S-11	4.95	0.53	5.80	S-11	3.48	2.30	5.80
S-2	5.50	0.60	7.90	S-12	3.03	1.66	12.86	S-12	3.80	1.90	12.86
S-3	3.52	2.83	-	S-13	3.12	2.20	19.51	S-13	6.22	1.90	3.63
S-4	3.79	5.42	2.07	S-14	2.46	1.81	2.68	S-14	1.94	13.07	3.75
S-5	1.62	2.12	-	S-15	3.83	2.02	1.80	S-15	3.96	2.02	2.07
S-6	2.59	0.99	2.90	S-16	2.60	0.44	13.59	S-16	3.82	-	-
S-7	1.62	1.5	3.08	S-17	3.36	1.10	24.80	S-17	3.82	0.96	13.39
S-8	1.56	1.86	3.01	S-18	2.92	NC	1.50	S-18	1.58	-	2.20
S-9	0.89	1.18	0.72	S-19	2.47	2.06	5.26	S-19	2.79	2.87	4.00
S-10	1.91	2.47	0.63	S-20	2.29	0	5.16	S-20	3.88	0	6.12
S-11	1.51	2.74	7.79	S-21	1.50	0.78	1.74	S-21	0.78	0.78	0.00
S-12	1.90	0.93	5.79	S-22	1.18	2.80	2.83	S-22	1.02	1.96	2.00
S-13	3.56	16.03	4.54	S-23	1.09	1.40	4.21	S-23	0.00	5.51	2.22
S-14	4.02	24.80	28.63	S-24	5.60	2.33	7.27	S-24	2.00	2.04	0.00
S-15	3.02	3.89	2.08	S-25	1.84	6.07	13.06	S-25	5.31	7.48	-
				S-26	4.21	1.46	3.13	S-28	2.96	1.83	-
				S-27	2.24	29.36	19.27				

Table 73. Generation wise performance of PB-1, PB-2 and Control for broiler traits

PB-1				PB-2				Control			
Gen.	BW 0	BW 5	FCR (upto 5 wks)	Gen.	BW 0	BW 5	FCR (upto 5 wks)	Gen.	BW 0	BW 5	FCR (upto 5 wks)
S-8	44.25	1041±2.77	2.16	S-21	44.1	1171±2.71	2.03	S-18	42.32	1008	2.08
S-9	39.86	1046±2.89	2.13	S-22	40.08	1018±3.73	2.25	S-19	40.25	808	2.51
S-10	40.63	1260±3.48	2.07	S-23	43.52	1085±5.14	2.38	S-20	40.87	728.6	2.64
S-11	42.82	1246±3.68	2.09	S-24	43.01	1126±6.99	2.35	S-21	34.72	814	2.57
S-12	43.39	1247±3.81	2.09	S-25	43.92	1093±6.40	2.21	S-22	40.05	719.9	2.71
S-13	42.72	1124±4.74	2.11	S-26	42.40	1097±6.03	2.09	S-23	40.15	562.4	3.98
S-14	41.69	956.2±7.50	2.16	S-27	41.60	947.2±8.41	2.15	S-24	40	662.7	3.84
S-15	40.72	1082±10.85	2.21	S-28	40.58	1017	2.18	S-25	39.11	717.6	2.38
								S-28	37.75	784.9	2.76

Egg production

Generations wise performance of PB-1, PB-2 and Control lines for egg production and allied traits *viz.*, body weight at 20 and 40 weeks, age at first egg, egg production at 40 and 52 weeks of age and egg weight at 32 weeks of age are presented in Tables 74, 75 and 76 respectively. Average body weight at 20 weeks of age in PB-1, PB-2 and control lines was 2389.52 g, 2346.85 g and 1840 g, respectively. Also, over the years, successful efforts have been made to restrict the body weight at 20 weeks of age in order to prolong age at sexual maturity and to have better persistency of egg production. The age at first egg was 187.64, 187.39 and 184.78 days for PB-1, PB-2 and control respectively. Also, over the years, attempts have been made to optimize body weight at 20 weeks and age at sexual maturity in all the strains for better egg production persistency. At 40 weeks of age, PB-1 weighed 3175.5 g, PB-2 3233.79 g and control 2908.33 g on an average. The results also indicated the effect of restricting body weight at 20 weeks on lowering the body weight at 40 weeks which, in turn, would yield more hatching eggs in the given cycle of production. The average egg production at 40 weeks was 79 eggs for

PB-1 and 58 eggs for control strains. Over the past few generations, this trait witnessed a decline for PB-2 strain and averages around 43 eggs. Egg production at 52 weeks witnessed a similar trend as egg production at 40 weeks and the corresponding values for PB-1, PB-2 and control lines was 114, 104 and 109 eggs respectively. Egg weight at 32 weeks of age was 55.53 g in PB-1, 56.13 g in PB-2 and 55.86 g in control strains. There is a declining trend in egg weight over the generations which is probably due to the increasing trend of egg production. This is expected since the egg weight and egg number are negatively correlated.

Genetic parameters

Heritability

The generation wise information on the number of sires used, 'K' coefficients computed and heritability estimates for the trait, body weight at 6 weeks of age have been are presented in Table 77.

The estimates of heritability for body weight at 6 weeks of age ranged from 0.14 (S3) to 0.38 (S-2) in PB-1 population while in PB-2 population, the estimates ranged from 0.01 (S-6) to 0.42 (S-2). All the heritability estimates were associated with low standard errors indicating their preciseness. There has been a significant reduction in the heritability estimates over the years indicating the increase in the uniformity of the population due to reduced additive genetic variation.

Correlation

In both PB-1 and PB-2 strains, body weight at 6-weeks was positively correlated with body weight at 20 weeks, body weight and at 40 weeks at genetic as well as phenotypic level. The strength of the correlation was medium to high, as per the expectation. The correlation between BW at 6 weeks with ASM was medium in magnitude and was negative in direction both at phenotypic at well as genetic level. The correlation between BW at 6 weeks with EP up to 40 weeks of age was very low and negative. In PB-1 and PB-2 strains, body weight at 20-weeks was positively and strongly correlated with body weight at 40 weeks both at genetic and phenotypic levels. The genetic correlation between BW at 20 weeks with ASM was medium in magnitude at genetic level and low in magnitude at phenotypic level. However, it was negative in direction both at phenotypic at well as genetic level. ASM was positively correlated at phenotypic level while negatively correlated at genetic level with egg production, although it was low in PB-2.

Response

The average phenotypic and genetic response of 5 weeks body weight in PB-1 was 7.88 and 20.61g over 15 generations, respectively. Corresponding values for egg production up to 40 weeks of age in PB-1 was -1.6 (15 generations) and -1.2 eggs (13 generations) (Figures 10 and 11). The average phenotypic and genetic response of 5 weeks body weight in PB-2 was 4.34 (15 generations) and 12.98 g (14 generations), respectively. Corresponding values for egg production in PB-2 up to 40 weeks was -2.02 (15 generations) and -1.13 eggs (14 generations) (Figures 12 and 13).

Table 74. Trend of egg production and allied traits over past few generations in PB-1

Traits	S-8	S-9	S-10	S-11	S-12	S-13	S-14
BW 20 (g)	2470	2229	2470	2390±22.85	2236±19.41	2465±18.45	2027±30.94
BW 40 (g)	3191		3160	3330±24.82	2861±26.92	3103±23.64	3152 ±32.34
ASM (days)			187.64	191.9±0.69	199.4±0.88	193.32±0.58	196.1±1.22
EW 32 (g)			55.53	60.04±0.51	58.77±0.50	55.20±0.30	54.50±0.52
EW 40 (g)				-	60.80±0.44	61.78±0.37	55.70±0.44
EW 52 (g)				53.10±0.67	54.52±0.88	43.59±0.77	37.41±0.89
EP 40 (Nos.)			63.81	86.98±0.94	95.02	65.51±0.81	65.06±1.33
EP 52 (Nos.)			114.22				

Table 75. Trend of egg production and other traits over past few generations in PB-2

Traits	S-20	S-21	S-22	S-23	S-24	S-25	S-26	S-27
BW 20 (g)	2690±17.99	2297±14.17	2178±15.87	2440±35.58	2550±28.91	2480±40.99	2320±20.05	2086±28.23
BW 40 (g)	3480±19.2	3253±27.42	3181±27.20	3200±35.10	3137±32.10	3488±36.38	3237±18.18	2894±29.26
ASM (days)	177.6±0.51	180.8±0.50	191.2±0.46	179.5±0.65	174.2±1.18	187.4±0.56	199.0±0.74	209.62±0.66
EW 32 (g)	56.72±0.20	56.42±0.33	57.10±0.33	55.20±0.42	56.65±0.52	57.52±0.47	54.92±0.29	54.52±0.46
EW 40 (g)							62.97±0.43	58.23±0.49
EP 40 (Nos.)	60.69±0.60	53.27±0.50	56.93±0.39	61.25±0.99	53.11±0.84	43.00	28.38±0.60	29.43±0.90
EP 52 (Nos.)	100.6±0.93	91.60±0.72	97.72±0.74	103.9±1.52	88.64±1.40	104.12	65.82±0.59	54.34±1.17

Table 76. Trend of egg production and other traits over past few generations in control population

Traits	S-19	S-20	S-21	S-22	S-23	S-24	S-25	S-28
BW 20 (g)		2050±46.09	1850±24.83	1740±26.21	1880±56.32	2120±42.95	1720±44.95	1520±20.60
BW 40 (g)		3020±52.57	2850±35.18	2850±44.55	2980±81.43	2650±52.92	3100±79.90	
ASM (days)	184.78	183.6±2.00	187.4±1.90	192.1±1.68	183.9±1,76	183.3±0.72	NR	
EW 32 (g)	55.86	52.48±0.52	51.85±1.02	52.40±0.67	50.97±1.07	48.44±0.51	54.63±0.91	
EW 40 (g)							56.03±1.03	
EP 40 (Nos.)	69.52	67.46±2.43	64.23±2.30	66.14±1.43	63.48±1.39	57.40±0.78	47.52	
EP 52 (Nos.)	118.7	115.74±2.53	99.31±2.47	117.4±1.69	109.5±2.28	100.8±1.58	99.82	

Table 77. Heritability estimates for body weight at 6 weeks in PB-1 and PB-2

Gen.	Heritability	
	PB-1	PB-2
S-1	0.30 ± 0.09	0.13 ± 0.04
S-2	0.38 ± 0.06	0.42 ± 0.07
S-3	0.14 ± 0.03	0.22 ± 0.05
S-4	0.21 ± 0.09	0.15 ± 0.07
S-5	0.15 ± 0.07	0.19 ± 0.03
S-6		0.01 ± 0.04
S-7		0.05 ± 0.01
S-8		0.18 ± 0.04
S-9		0.13 ± 0.03

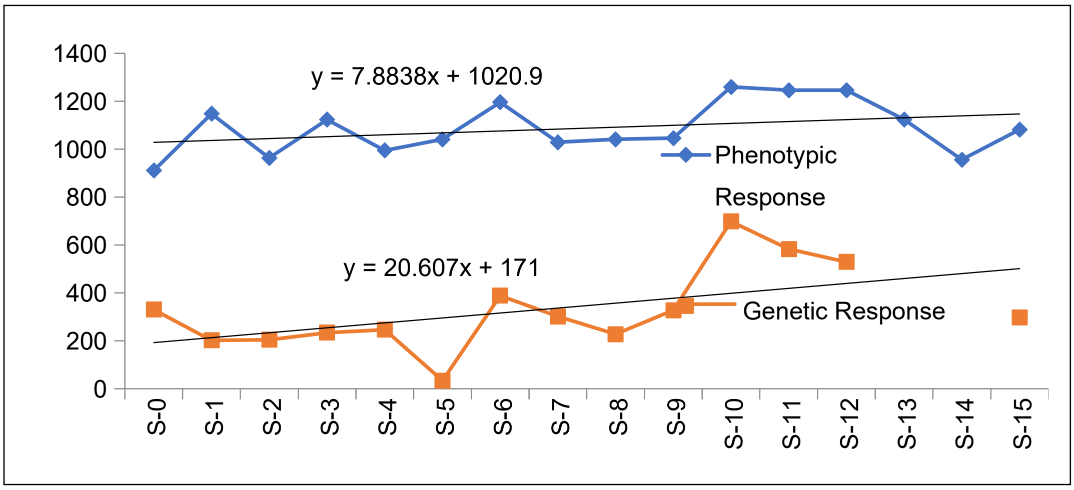


Figure 10: Genetic and phenotypic response to 5 weeks body weight in PB-1

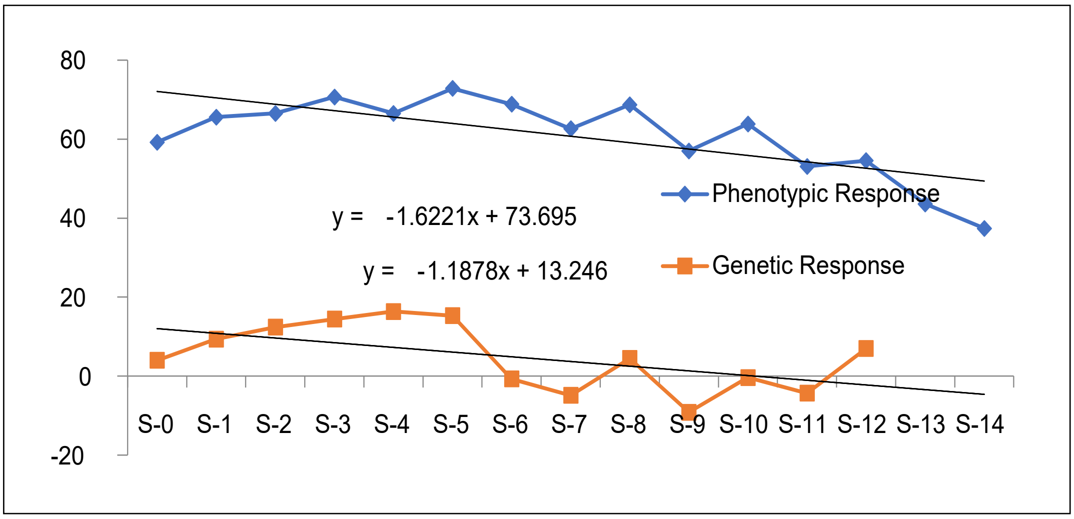


Figure 11: Genetic and phenotypic response of egg production up to 40 wks in PB-1

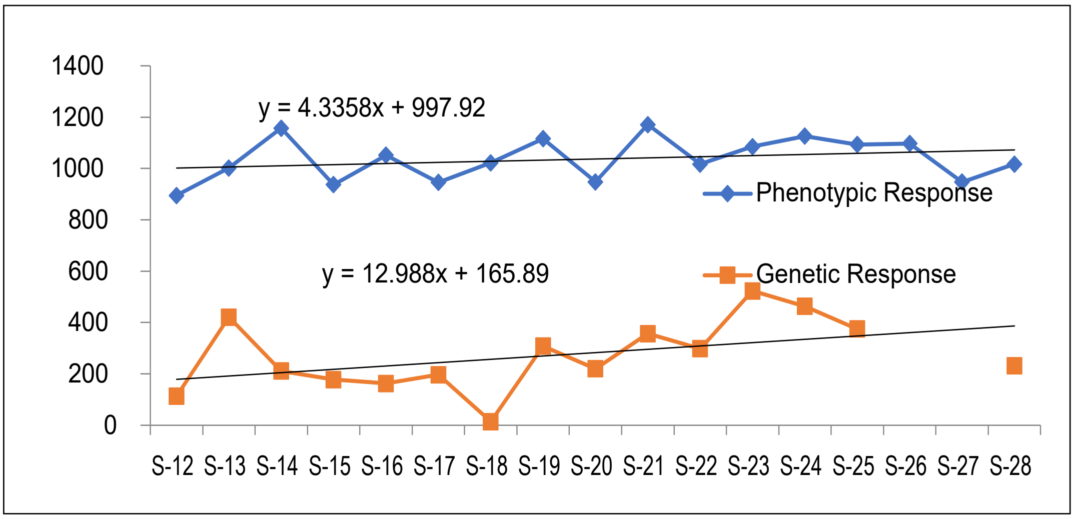


Figure 12: Genetic and phenotypic response to 5 weeks body weight in PB-2

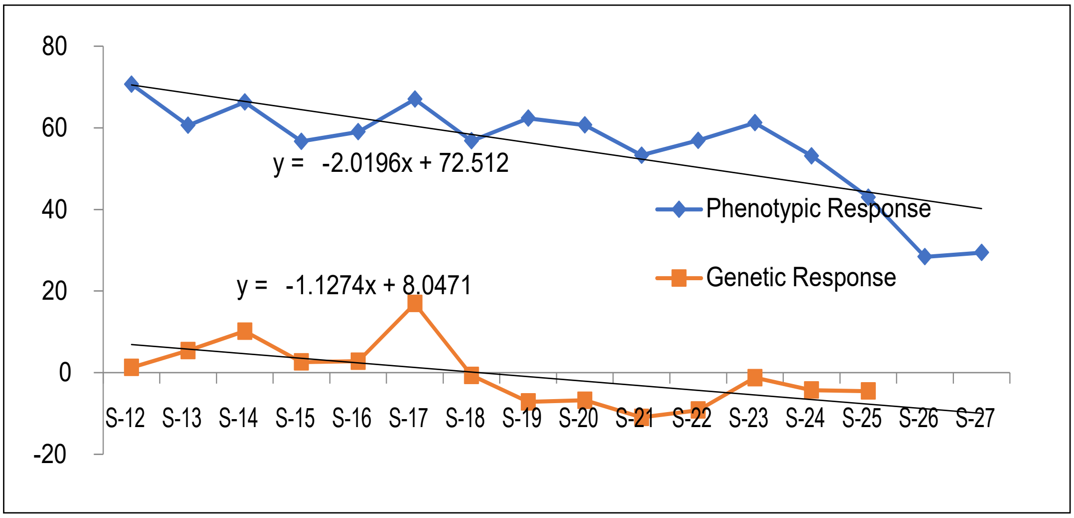


Figure 13: Genetic and phenotypic response of egg production up to 40 wks in PB

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Ludhiana centre was sanctioned during the year 1975 but it started functioning from 1st April, 1977. Since inception, The centre has been working on PB-1 and PB-2 lines. 8 weeks body weight was the criteria of selection from 1977-78 to 1980-81, 6 weeks body weight from 1981-82 to 2001-2002 and 5 weeks body weight from 2002-03 onwards.

The strains PB-1 and PB-2 were developed from the synthetic base populations constituted from the inter-se mating of commercial stocks. The strain PB-1 is selected mainly for increased growth rate while PB-2 was initially selected for juvenile growth and later subjected to another selection for egg number to 280 days of age (sire family average basis). Both the populations are selected for better body conformation and against physical defects of keel bone, legs, beak and back.

Achievements

Selection records

A summary of selection records for PB-1 and PB-2 for the initial generations and last twelve generations have been presented in Tables 78 and 79 respectively. The average number of sires and dams that have contributed in the initial generations (1977-78 to 2003-04) were 50 and 304 respectively. In the past twelve generations (2010-11 to 2021-22), these numbers have significantly increased to 85 and 458 respectively. Also, the effective population size rose from 168.8 in the initial years to 308.5 in the past few generations. This indicates that genetic variability is being continuously introduced to avoid the negative consequences of long-term selection. In PB-1, the average intensity of selection in males and females was 1.4 and 1.24 respectively while in PB-2, it was slightly higher as 1.59 and 1.39 for males and females respectively (Table 79). However, the expected response was 23.65 in PB-1 and 16.5 in PB-2 lines as the selection differential was higher in the former (138.28) than the latter (113.37) (Table 79).

Incubation records

The fertility and hatchability records of PB-1, PB-2 and control strains from 1977-78 to 2003-04 have been summarized in Table 80 while those from 2010-11 to 2021-22 have been given in Table 81. A detailed study of the long-term data of PB-1 indicates that the average fertility value increased from 79.2 to 87.5% over the generations. Also, the average total egg set hatchability experienced a rise from 68.0 to 77.3% over the studied period. In PB--2, a strikingly similar trend was observed with the average fertility and total egg set hatchability increasing from 84.1 to 92.9% and 72.8 to 82.7% respectively. The fertile egg set hatchability remained 86% for PB-2 as well (Tables 80 and 81). For control population, a dip was witnessed in all the parameters over the generations with average fertility declining from 82.1 to 72.9%, average total egg set hatchability from 71.6% to 62.5% and fertile eggs set hatchability from 86.5 to 80.2% (Tables 80 and 81).

Table 78. Selection records in the initial generations (1977-78 to 2003-04)

Year	Strain	No. of sires used	No. of dams used	Effective number	SI males	SD females	Selection intensity	Expected response
1977-78	PB-1	50	150	150	217.7	105.7	1.303	48.5
	PB-2	41	164	131.2	211.5	125.5	1.171	50.0
1978-79	PB-1	50	200	160	183.8	92.5	1.206	41.4
	PB-2	50	200	160	199.6	82.1	1.045	42.0
1979-80	PB-1	50	200	160	204.0	108.0	1.201	46.8
	PB-2	51	204	163.2	241.0	96.0	1.182	50.5

Year	Strain	No. of sires used	No. of dams used	Effective number	SI males	SD females	Selection intensity	Expected response
1980-81	PB-1	47	188	150.4	205.0	104.0	1.211	46.3
	PB-2	46	229	153.2	247.0	89.0	1.160	50.4
1981-82	PB-1	50	200	169.0	177.0	71.0	1.777	37.2
	PB-2	50	231	164.4	202.0	64.0	1.137	39.9
1982-83	PB-1	51	247	169.1	174.0	56.0	1.116	34.6
	PB-2	50	255	167.2	165.0	73.0	1.173	35.7
1983-84	PB-1	43	175	138.1	158.4	60.3	1.230	32.7
	PB-2	54	297	132.8	166.8	87.4	1.185	38.1
1984-85	PB-1	48	233	159.2	171.0	62.0	1.076	34.8
	PB-2	52	269	174.3	196.0	60.0	1.184	38.4
1985-86	PB-1	53	269	177.1	198.0	63.1	1.110	39.1
	PB-2	64	308	211.9	190.7	47.9	1.050	33.0
1986-87	PB-1	55	270	182.8	154.6	65.8	1.005	33.0
	PB-2	62	304	206.0	186.7	61.8	0.821	37.2
1987-88	PB-1	39	194	129.9	183.1	63.4	0.850	36.9
	PB-2	60	300	200.0	204.8	70.0	1.033	41.2
1988-89	PB-1	39	184	128.1	100.8	65.3	1.122	38.4
	PB-2	60	295	199.4	200.2	80.9	1.223	39.2
1989-90	PB-1	42	188	137.3	180.6	66.0	0.484	36.9
	PB-2	55	269	182.6	215.1	78.2	1.047	43.8
1990-91	PB-1	40	202	132.6	183.0	63.0	0.838	36.9
	PB-2	60	300	199.0	186.6	72.0	0.925	38.7
1991-92	PB-1	40	214	134.8	95.0	75.0	0.570	25.5
	PB-2	54	314	184.3	145.0	81.0	0.600	33.9
1992-93	PB-1	44	396	111.0	190.0	69.5	1.150	38.5
	PB-2	64	449	179.7	115.0	64.0	0.650	26.8
1993-94	PB-1	44	440	160.0	214.0	59.5	0.994	41.0
	PB-2	60	480	212.4	201.5	83.5	1.042	42.6
1994-95	PB-1	44	437	159.9	250.5	51.9	1.000	45.5
	PB-2	50	390	177.3	184.9	94.2	0.889	41.8
1995-96	PB-1	44	305	159.9	248.2	51.4	1.060	44.9
	PB-2	50	382	175.9	186.1	91.3	1.050	41.6
1996-97	PB-1	44	308	154.0	263.0	115.0	1.32	59.7
	PB-2	50	350	175.0	236.0	81.1	1.19	47.5
1997-98	PB-1	50	350	159.0	182.6	64.0	1.20	36.6
	PB-2	50	450	181.0	177.4	56.3	1.0	33.6
1998-99	PB-1	50	350	174.8	295.6	121.5	1.0	62.5
	PB-2	50	400	177.6	207.8	80.1	1.11	44.0
1999-2000	PB-1							
	PB-2	60	480	213.3	171.0	78.3	0.58	37.3
2000-01	PB-1							
	PB-2	63	504	224.0	195.9	67.8	0.638	39.5
2001-02	PB-1	36	180	120.0	178.4	111.2	0.711	43.4
	PB-2	53	525	192.5	287.0	117.0	1.30	60.6
2002-03	PB-1	33	232	115.8	245.7	131.8	1.21	56.6
	PB-2	70	560	248.8	271.9	76.0	1.26	51.8

Year	Strain	No. of sires used	No. of dams used	Effective number	SI males	SD females	Selection intensity	Expected response
2003-04	PB-1	47	251	154.8	284.8	102.8	1.25	58.1
	PB-2	69	549	243.8	193.2	79.2	1.08	40.8

Table 79. Selection records over the past twelve generations (2010-11 to 2021-22)

Year	Strain	No. of sires used	No. of dams used	Effective number	Average effective SD	SI ()		Expected response
						Males	Females	
2010-11	PB-1	101	505	348.12	132	1.39	0.86	19.4
	PB-2	108	648	370.3	104.0	1.11	0.65	15.9
2011-12	PB-1	117	585	390.0	87.0	0.48	0.61	12.18
	PB-2	130	650	433.0	104.0	1.78	1.06	14.56
2012-13	PB-1	124	600	411.0	90.0	0.52	0.56	20.7
	PB-2	123	613	410.0	105.0	1.21	1.48	29.2
2013-14	PB-1	84	424	280.0	169.0	1.05	1.06	NR
	PB-2	120	601	400.0	137.5	1.27	0.98	NR
2014-15	PB-1	67	402	230.0	140.2	1.3	0.9	16.96
	PB-2	83	498	285.0	109.1	1.11	1.2	13.34
2015-16	PB-1	72	456	248.7	211.5	0.04	0.03	29.70
	PB-2	80	480	270.5	120.6	0.04	0.03	17.47
2016-17	PB-1	62	349	252.0	-	3.14	2.96	52.36
	PB-2	80	480	744.1	-	3.17	2.99	29.48
2017-18	PB-1	62	372	213.0	-	3.32	2.96	2.90
	PB-2	80	480	274.0	-	3.09	2.76	0.88
2018-19	PB-1	70	400	238.0	-	-	-	23.04
	PB-2	70	410	239.0	-	-	-	23.63
2019-20	PB-1	70	350	233.3	-	-	-	39.19
	PB-2	70	350	233.3	-	-	-	24.67
2020-21	PB-1	70	350	233.3	-	-	-	21.87
	PB-2	60	300	200.0	-	-	-	6.11
2021-22	PB-1	70	350	233.3	-	-	-	21.87
	PB-2	70	350	233.3	-	-	-	7.10

Table 80. Fertility and hatchability in the initial generations

Years	PB-1			PB-2			Control		
	Fertility (%)	Hatchability (%)		Fertility (%)	Hatchability (%)		Fertility (%)	Hatchability (%)	
		TES	FES		TES	FES		TES	FES
1977-78	58.2	54.3	93.3	61.7	55.7	90.4	59.1	54.1	91.7
1978-79	68.5	63.0	92.0	74.1	68.1	91.8	74.5	67.8	92.3
1979-80	71.7	66.2	92.2	78.7	71.1	90.4	82.6	77.7	94.1
1980-81	73.6	65.0	88.3	80.2	69.9	87.1	84.5	75.1	88.8
1981-82	78.6	70.7	90.0	83.6	74.4	88.9	81.2	74.5	91.7

Years	PB-1			PB-2			Control		
	Fertility (%)	Hatchability (%)		Fertility (%)	Hatchability (%)		Fertility (%)	Hatchability (%)	
		TES	FES		TES	FES		TES	FES
1982-83	77.6	64.1	82.6	81.5	67.3	82.6	79.3	67.1	64.8
1983-84	67.5	54.2	80.3	76.7	62.6	81.6	64.9	55.1	84.8
1984-85	82.9	77.2	93.1	90.0	82.4	91.5	88.0	83.1	93.4
1985-86	78.1	69.5	88.9	89.4	80.2	89.7	94.8	88.4	93.2
1986-87	76.7	65.3	85.3	86.4	78.4	90.7	82.8	76.4	92.2
1987-88	74.0	67.4	91.1	82.2	77.0	93.9	70.6	66.1	93.7
1988-89	81.0	74.1	91.5	90.5	89.1	87.5	86.0	79.0	92.2
1989-90	73.7	65.7	89.2	88.1	70.8	89.4	83.4	76.4	91.6
1990-91	82.8	75.3	90.9	90.4	82.5	91.2	92.2	81.2	88.1
1991-92	78.4	69.1	88.1	87.7	81.5	92.9	92.0	84.6	91.8
1992-93	62.5	55.6	88.9	85.0	74.1	87.3	91.3	85.6	93.7
1993-94	85.4	65.7	76.9	91.6	80.1	88.4	89.8	88.1	97.2
1994-95	84.6	71.4	84.3	86.9	77.8	89.4	87.5	68.9	78.8
1995-96	80.4	68.9	85.6	90.6	78.4	86.4	85.4	63.8	72.6
1996-97	84.6	70.3	83.0	85.7	63.7	74.2	83.4	71.0	85.1
1997-98	89.1	71.2	79.9	91.1	73.5	80.6	80.6	56.5	79.9
1998-99	87.2	62.2	71.4	90.8	74.3	81.8	87.8	70.4	80.2
1999-2000	92.9	74.4	80.0	61.2	39.2	62.3	77.9	55.3	71.0
2000-01	91.0	66.0	72.5	91.0	65.0	71.4	-	-	-
2001-02	83.6	78.2	93.5	82.3	72.8	88.4	76.8	56.1	70.3
2002-03	88.4	77.2	87.3	88.0	79.2	90.0	80.9	75.5	93.3
2003-04	84.8	75.3	88.7	85.4	77.2	90.4	78.7	64.3	81.7

Table 81. Fertility and hatchability in last twelve generations

Years	PB-1			PB-2			Control		
	Fertility (%)	Hatchability (%)		Fertility (%)	Hatchability (%)		Fertility (%)	Hatchability (%)	
		TES	FES		TES	FES		TES	FES
2010-11	89.3	79.8	88.5	94.1	82.8	88.0	68.2	50.0	73.1
2011-12	93.2	76.4	81.9	91.1	81.7	87.3	-	32.1	-
2012-13	87.7	60.9	69.4	94.8	85.5	90.2	-	60.0	-
2013-14	77.7	66.5	85.6	94.7	75.0	79.2	51.1	-	51.1
2014-15	95.9	85.7	89.3	93.0	82.7	88.9	23.8	19.3	81.0
2015-16	92.6	80.0	86.4	94.6	87.7	92.8	64.8	50.0	77.1
2016-17	73.3	65.0	88.6	95.2	89.4	93.9	98.2	72.3	73.7
2017-18	73.9	57.8	78.2	80.1	48.8	61.9	71.9	64.6	89.8
2018-19	89.6	84.1	93.9	96.2	82.3	85.6	82.6	78.6	95.2
2019-20	89.0	83.2	93.4	92.3	87.4	94.7	83.7	72.6	86.8
2020-21	94.7	95.4	90.3	94.8	92.9	88.1	96.5	94.8	91.5
2021-22	93.8	93.7	87.7	93.9	97.0	91.1	88.7	93.4	82.8

Body weight and feed conversion

Live weight to the marketable age is the most important trait in broilers. Initially, the selection for juvenile growth was based on eight-week body weight (1977-78 to 1980-81). The criterion of selection was subsequently changed to six-week body weight (1981-82 to 2001-02) and thereafter, reduced to five-week body weight (2002-03 onwards).

The average body weights and feed conversion values are presented in Tables 82 and 83. Over the past few generations, the average body weight at five weeks of age in PB-1, PB-2 and control populations was 1167.4, 1054.5 and 858.7 gm respectively (Table 83). The phenotypic and genetic response plotted over the generations indicated that body weight at five weeks improved by 3.55 gm per generation in PB-1 line (Figure 14). However, in PB-2 line, it has deteriorated as a decrease of 5.76 gm has been witnessed over the generations (Figure 15).

Table 82. Average body weight and feed conversion to 5 weeks of age

Years	PB-1		PB-2		Control	
	BW 5 (g)	FCR	BW 5 (g)	FCR	BW 5 (g)	FCR
1977-78*	995	2.70	1077	2.65	906	2.77
1978-79*	1338	2.39	1351	2.34	1169	2.44
1979-80*	1445	2.46	1479	2.32	1195	2.54
1980-81*	1386	2.41	1404	2.44	1112	2.54
1981-82**	906	2.45	942	2.27	954	2.53
1982-83**	1049	2.41	1060	2.40	979	2.52
1983-84**	978	2.44	971	2.42	739	2.57
1984-85**	893	2.34	901	2.37	645	2.73
1985-86**	1012	2.44	956	2.32	622	2.51
1986-87**	1020	2.70	986	2.80	650	3.17
1987-88**	878	2.73	979	2.76	652	2.89
1988-89**	918	2.46	907	2.76	601	2.70
1989-90**	1155	2.33	1183	2.26	802	2.30
1990-91**	1242	2.34	1304	2.56	847	2.68
1991-92**	975	3.07	1017	2.77	680	2.03
1992-93**	1099	2.28	1055	2.11	667	2.48
1993-94**	1163	2.43	1087	2.38	777	2.46
1994-95**	1081	2.48	1027	2.55	827	2.68
1995-96**	1097	2.46	1049	2.53	705	2.69
1996-97**	1199	2.2	1125	2.40	690	2.20
1997-98**	1123	2.21	1100	2.34	690	2.45
1998-99**	1224	2.18	1392	2.21	825	2.65
1999-2000**	1228	2.35	873	2.66	692	2.75
2000-01**	1195	2.10	1016	2.32	-	-
2001-02**	1088	-	1200	-	712	2.46
2002-03***	1102	2.16	900	2.00	787	2.49
2003-04***	1172	2.28	868	2.03	726	2.40

*Information recorded to eight weeks of age, **Information recorded to six weeks of age, ***Information recorded to five weeks of age.

Table 83. Average body weight and feed conversion ratio to 5 weeks of age in the last twelve generations

Years	PB-1		PB-2		Control	
	BW 5 (g)	FCR	BW 5 (g)	FCR	BW 5 (g)	FCR
2010-11	1167	2.07	1155	2.21	951	2.09
2011-12	1143	2.13	1024	2.24	936	2.29
2012-13	1178	2.40	1189	2.10	975	2.30
2013-14	1068	1.95	1065	1.60	604	1.17
2014-15	1271	1.93	1024	1.80	744.65	1.72
2015-16	1089±3.7	2.1	929.42±2.84	2.20	784.72±11.07	1.90
2016-17	1157±4.3	2.0	1061.62±3.54	2.10	946.87±19.35	1.90
2017-18	1200±3.78	2.1	934±7.24	1.90	871.40±10.58	2.20
2018-19	1166±4.06	1.91	1071±2.96	1.94	826.0±10.59	2.02
2019-20	1125±3.59	1.95	1049±7.49	1.93	774.8±9.98	1.97
2020-21	1202±4.13	1.87	1000±9.98	1.89	921.6±7.76	1.91
2021-22	1241±3.37	1.88	1152±5.54	1.89	968.4±8.19	1.90

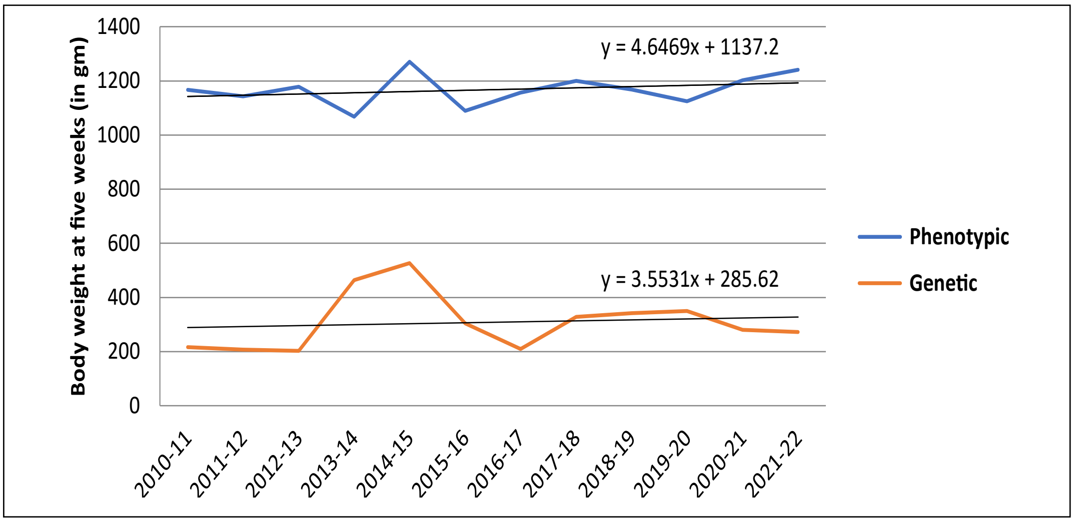


Figure 14: Phenotypic and genetic response for body weight at five weeks (BW5) over the generations in PB-1 line

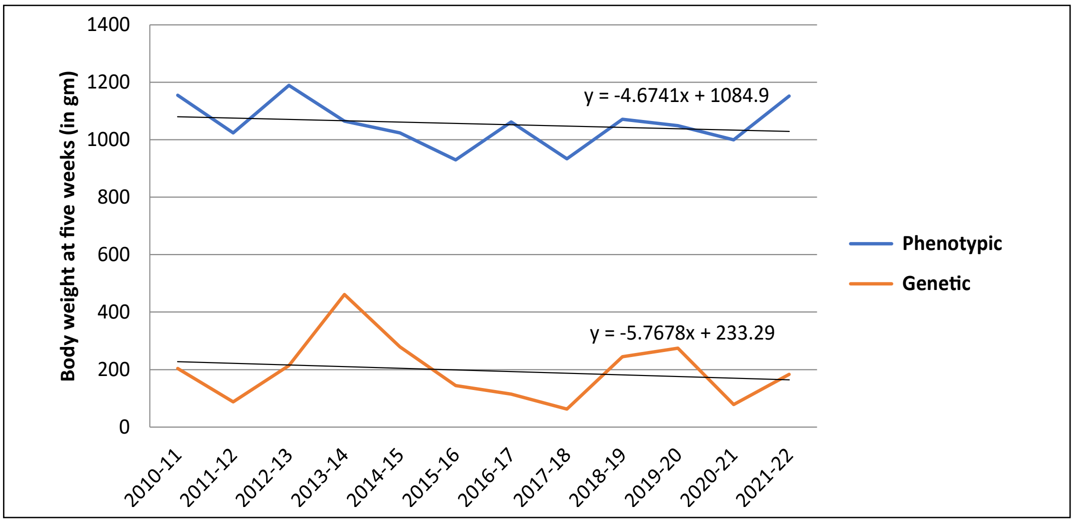


Figure 15: Phenotypic and genetic response for body weight at five weeks (BW5) over the generations in PB-2 line

The heritability estimates for body weight at 8/6/5 weeks of age from 1978-79 to 2003-04 are presented in Table 84. Analysis of the estimates over the generations suggests that the average heritability of the trait is 0.30 in both the populations. Individual estimates also show that it is majorly a medium to high heritability trait.

Table 84. Heritability estimates of body weight at 8/6/5 weeks for PB-1 and PB-2

Years	PB-1	PB-2	Years	PB-1	PB-2
1978-79*	0.28	0.16	1991-92**	0.34	0.27
1979-80*	0.19	0.63	1992-93**	0.19	0.31
1980-81*	0.59	0.41	1993-94**	0.22	0.33
1981-82*	0.33	0.59	1994-95**	0.28	0.23
1982-83**	0.46	0.41	1995-96**	0.31	0.29
1983-84**	0.28	0.18	1996-97**	0.28	0.28
1984-85**	-ve	0.23	1997-98**	0.29	0.31
1985-86**	0.14	0.35	1998-99**	0.30	0.28
1986-87**	0.22	0.31	1999-2000**	0.27	0.39
1987-88**	0.43	0.22	2000-01**	-	0.27
1988-89**	0.38	0.30	2001-02	-	-
1989-90**	0.31	0.05	2002-03***	0.29	0.32
1990-91**	0.29	0.25	2003-04***	0.34	0.31

* For eight weeks body weights , ** For six weeks body weights,
*** For five weeks body weights

Along with the juvenile growth, the efficiency of growth measured as feed conversion is an important trait. Feed conversion values for five weeks body weight averaged around 1.97 for both PB-1 and PB-2 and 1.94 for control (Tables 82 and 83). In general, the values varied from 1.87 to 4.13 for PB-1 line and 1.89 to 1.93 for PB-2 line. The feed conversion has improved over years. The regression of feed conversion values deviated from the control plotted over generations indicated a genetic gain of -0.018 in the strain PB-1 and -0.013 in the strain PB-2 (Figures 16 and 17).

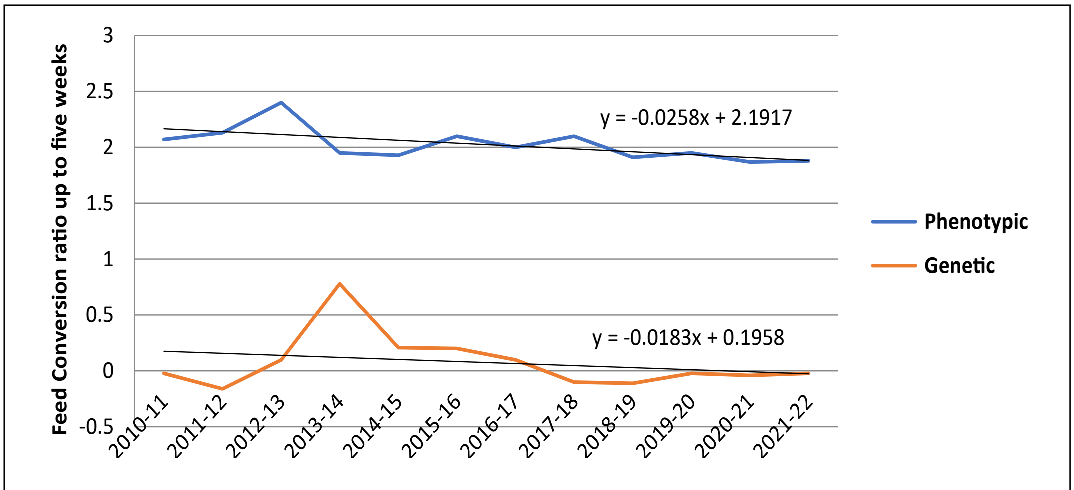


Figure 16: Phenotypic and genetic response for feed conversion ratio up to five weeks (FCR5) over the generations in PB-1 line

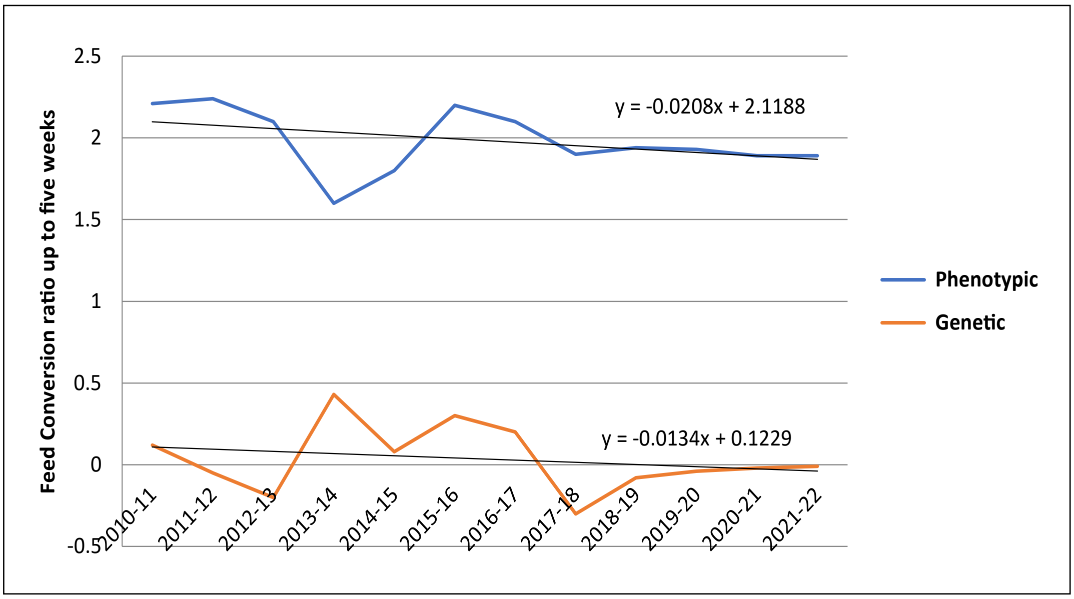


Figure 17: Phenotypic and genetic response for feed conversion ratio up to five weeks (FCR5) over the generations in PB-2 line

Production traits

In broiler breeders, the environmental factors play a major role. The selected populations never express their full potential as body weight control through feed restriction starts only after the birds are selected and moreover, the selected lots have the average body weight much more than desirable at that age. The environmental factors controlling the production include: the feed restrictions during the growing/laying periods, rate and uniformity of growth, season, feed and light programmes etc. Diseases during growing periods particularly Coccidiosis, adversely affect the uniformity of growth and ultimately, the onset, peak and persistency of egg production.

Age at sexual maturity and body weight traits

Strain PB-2 was selected and improved as a female line. Therefore, PB-2 strain had lowest average age at sexual maturity (171.86 days) with the range varying from 149 to 206 days. The average values for ASM for PB-1 and Control over the generations were 186.46 and 185.67 days respectively.

For the trait body weight at 20 weeks (BW20), the overall averages were 2288, 2250 and 2017 for PB-1, PB-2 and Control respectively. However, if we consider only the last twelve generations, the corresponding values for PB-1 and PB-2 were 2411 and 2247 respectively. These was a significant increase for PB-1 which reported BW20 of 2206 during the initial years while PB-2 witnessed a slight decrease from 2251 to 2247 between the initial generations and past twelve generations. Performance of ASM and body weight traits over the generations is presented in Table 85.

Table 85. Performance of body weight traits and age at sexual maturity over the generations

Year	ASM (d)			BW 20 (g)			BW 40 (g)		
	PB-1	PB-2	PB--4	PB-1	PB-2	PB--4	PB-1	PB-2	PB--4
1977-78	177±1.4	165±1.6	181±2.5	Not recorded			3508±29	3532±47	2993±28
1978-79	182±2.1	162±1.4	177±1.4	2696±12	2778±15	2481±16	3796±36	3790±31	3505±36
1979-80	180±0.8	168±0.6	175±1.1	2444±12	2525±60	2188±24	4273±25	4106±18	3492±58
1980-81	176±0.9	188±0.8	169±1.5	2502±16	2452±16	2145±45	4116±25	3729±19	3859±35
1981-82	173±1.1	173±0.9	165±1.5	2588±21	2609±8	2337±18	4022±18	3645±19	3536±55
1982-83	186±0.62	183±0.45	167±0.80	2206±10	2204±7	2047±11	3909±19	3580±13	3481±28
1983-84	212±1.1	172±0.8	186±0.59	2130±16	2492±8	1908±35	3445±31	3366±11	2886±35
1984-85	220±1.3	206±0.9	214±0.0	2061±10	2035±7	1883±24	2913±20	3106±11	2690±28
1985-86	215±1.9	189±1.3	180±0.0	2049±10	2149±7	2018±14	3729±34	3279±19	2914±48
1986-87	200±1.8	178±1.3	170±0.0	2264±11	2229±6	2208±16	3525±29	3326±8	2884±32
1987-88	215±2.2	185±1.8	199±0.0	2070±14	2152±15	1881±17	3299±24	3250±12	2763±21
1988-89	210±3.9	176±0.8	200±0.7	1968±19	2011±12	1877±17	3252±27	3152±19	2471±16
1989-90	-	-	-	2175±0	2289±0	1980±0	3580±0	3663±0	2930±0
1990-91	217±0.0	165±0.9	189±0.0	2402±18	2363±11	2135±31	3543±43	3333±29	2946±41
1991-92	235±0.0	183±0.8	198±0.0	1886±16	1881±13	1771±33	2977±29	2996±28	2700±42
1992-93	-	202±1.1	215±0.0	1678±17	1766±16	1406±38	3411±31	3812±23	2511±51
1993-94	-	178±0.9	-	2107±18	2223±15	-	3213±27	3070±21	2830±40
1994-95	-	160±0.7	-	2277±15	2263±12	-	3454±34	3215±24	-
1995-96	-	178±0.5	-	2205±10	2106±7.3	-	3573±20	3399±13	-
2010-11	162	157	172	2233	2177	2224	3206	3082	3363
2011-12	157	165	178	2206	2179	2126	3442	3081	3442
2012-13	167	149	155	2309	2238	2277	2913	2821	2913
2013-14	179	157	160	2435	2210	2432	3368	2739	3368
2014-15	170	153	175	2559	2185	2099	2796.4	2855	2796
2015-16	174±0.7	161±0.4	183±2.87	2659±11.8	2327±9.1	2285±26.2	3144±24.9	2848±13.4	3144±24.9
2016-17	181±0.4	163±1.1	201±3.83	2510±11.5	2298±7.9	2127±36.7	3287±46.2	2603±9.4	3287±46.2
2017-18	168±0.5	157±0.8	186±1.79	2445±9.6	2319±12.1	2417±15.5	3277±22.8	2886±11.7	3277±22.8
2018-19	153±0.8	171±1.3	181±5.43	2505±10.2	2174±8.6	2042±46.9	2856±57.2	2988±11.9	2856±57.2
2019-20	184±0.5	169±1.6	176±9.03	2331±10.2	2280±11.6	2110±38.3	2982±42.1	2879±16.3	2982±42.1
2020-21	179±0.5	170±2.3	178±28.0	2357±12.9	2287±27.9	2193±18.3	2903±17.1	2974±28.2	2903±17.1
2021-22	176±1.1	173±1.7	179±18.1	2385±10.1	2299±14.2	2211±8.9	2946±12.6	3013±2.9	2946±12.6

The averages for body weight at 40 weeks (BW40) was 3376, 3229 and 3023 for PB-1, PB-2 and Control respectively. During the last twelve generations (2010-11 to 2021-22), there was a decline in BW40 for all the traits with PB-1 registering a decrease of 12.97% and PB-2 showing a decrease of 15.7% for the trait.

In broilers, juvenile body weight and egg production are antagonistic to each other. Poultry breeders find it difficult to improve both the traits simultaneously in the desirable direction. In order to maximize the production of eggs, they worked out the desired body weights at different ages of the bird's life. In order to achieve the required results, they started controlling the growth during growing and laying periods through feed restriction.

Selected birds are kept on a daily feed restriction programme. During the growing period, the variation in body weights at different ages is intentionally reduced by increasing the levels of feed for the groups having body weight less than the desired and the feed levels of heavier birds are not increased at the required rates i.e. in order to get optimum production from the selected birds, we do not allow the natural variation to express itself. Secondly, the mass selection for juvenile body weight leads to unwanted variation in sire/dam family size. The genetic parameters estimated from such stocks are inconsistent and cannot be relied upon.

Egg production

In addition to the juvenile growth, body conformation and physical body defects, the sire-family averages for egg production to 280 days was the main criterion of selection for the strain PB-2. In this strain, the overall egg production to 40 week of age (EP40) averaged over all generations was 65.76. However, a significant increase has been made in the past twelve generations as the average value rose to 71.36. Also, for PB-1, the average value for EP40 increased from 41.43 to 59.95 over the generations. The egg production to 52 weeks of age (EP52) recorded over the past twelve generations is 106.32, 116.25 and 93.49 for PB-1, PB-2 and control populations respectively. The egg production values are presented in Table 86.

Egg weight

In broiler breeders, the egg weight is important due to the reason that it leads to the production of healthy chicks which may grow well. The variation in egg weights at 36-40 weeks and 52 weeks over the generations is depicted in Table 86. Initially, the egg weights from 36-40 weeks for PB-1 and PB-2 strains were almost similar as 60.26 and 59.54 g respectively. However, over the past few generations, the corresponding egg weights have declined to 56.20 and 55.32 g. For the trait egg weight at 52 weeks, the reported average values over the past twelve generations were 63.86 and 61.76 g for PB-1 and PB-2 strains respectively.

Egg quality traits

The egg quality traits of PB-1 and PB-2 strains evaluated over the generations have been described in Table 87. The average values for egg length (cm), egg width (cm), shape index, shell thickness (mm), albumen height (mm), yolk height (mm), yolk index and Haugh unit in both the strains were 5.5, 4.26, 70.59, 0.31, 8.53, 17.31, 4.39 and 95.72 respectively.

Response

The phenotypic and genetic response for primary trait and correlated traits over the years 2010-11 to 2021-22 is presented in Table 88.

Table 86. Performance of egg production and egg weight traits over the generations

Year	EP 40 (Nos.)			EP 52 (Nos.)			EW 40 (g)			EW 52 (g)		
Years	PB-1	PB-2	Control	PB-1	PB-2	Control	PB-1	PB-2	Control	PB-1	PB-2	Control
2010-11	61.3	83.8	69.6	110.7	134.5	106	58.5	57.5	55.4	65.5	62.3	62.0
2011-12	80.2	88.2	69.7	116.6	127.9	106.2	58.05	59.5	56.3	64.3	65.2	60.7
2012-13	67.8	82.3	80.9	108.1	128.5	111.2	56.86	56.95	55.60	64.5	64.2	63.5
2013-14	56.2	80.6	73.2	133	125	122	56.9	57.1	57.8	63.0	61.20	62.0
2014-15	55.3	55.7	34.4	69.8	84.7	60.5	58.1	57.02	53.68	66	62.7	63.3
2015-16	59.42	83.9	49.21	75.08	112.2	83.42	58.61	60.45	53.10	62.9	62.18	61.28
2016-17	48.48	75.98	38.12	100.10	116.5	-	51.50	47.61	49.04	63.77	53.54	-
2017-18	58.43	68.43	41.50	111.43	103.51	55.11	56.56	51.31	47.46	64.16	58.73	58.49
2018-19	64.66	68.61	55.36	112.38	112.75	89.36	54.45	54.15	54.43	60.52	57.46	57.42
2019-20	59.38	57.39	58.65	112.12	113.37	95.87	55.40	52.10	52.41	64.08	64.01	60.01
2020-21	53.27	55.27	50.12	111	117.81	98.16	54.41	54.03	52.69	63.12	63.98	61.34
2021-22	55.02	56.13	51.22	115.6	118.3	100.6	55.07	56.09	54.26	64.51	65.66	62.73

Table 87. Performance of egg quality traits in different strains

Year	Strain	EW 40 (g)	Shape Index	Shell thickness (mm)	Yolk index	Haugh unit
2010-11	PB-1					
	PB-2	58.5±0.2	76.9±1.6	0.31±0.02	5.03±0.2	94.2±2.1
	Control	55.4±0.7	75.8±1.2	0.33±0.03	4.87±0.2	93.01±2.2
2011-12	PB-1					
	PB-2	59.5±0.2	75.9±1.6	0.3±0.02	4.9±0.2	94.2±2.1
	Control	56.4±0.7	75.3±1.2	0.32±0.03	4.9±0.2	93.31±2.2
2012-13	PB-1					
	PB-2	58.5±0.19	74.9±1.9	0.26±0.03	4.99±0.2	95.1±1.9
	Control	55.5±0.7	74.9±1.12	0.24±0.01	4.6±0.2	94.3±2.4
2013-14	PB-1					
	PB-2	57.5±0.4	72.4±1.3	0.36±0.3	4.98±0.5	95.4±2.5
	Control	56.4±0.8	73.3±2.2	0.33±0.1	4.87±0.2	94.3±1.2
2014-15	PB-1					
	PB-2	55.5±0.15	70.92±0.6	0.31±0.01	21.7±0.3	83.9±1.2
	Control	53.9±0.7	70.87±0.8	0.29±0.01	21.7±0.3	81.9±1.13
2015-16	PB-1	57.5±0.6	75.1±0.6			
	PB-2	58.4±0.5	75.0±0.5			
	Control	58.1±0.8	74.9±0.7			
2016-17	PB-1	52.5±0.9	74.3±1.0			123.7
	PB-2	52.6±0.6	75.5±0.5			122.36
	Control					
2017-18	PB-1	54.6±0.7	75.5±0.5			
	PB-2	57.9±0.7	74.25±0.5			
	Control	57.9±1.1	75.4±0.7			
2018-19	PB-1	56.5±0.6	75.6±0.7		4.32	90.78
	PB-2	55.07±0.3	76.3±0.6		4.22	87.90
	Control	54.4±0.7	74.9±0.5		4.34	93.65

Year	Strain	EW 40 (g)	Shape Index	Shell thickness (mm)	Yolk index	Haugh unit
2019-20	PB-1	55.4±0.2	76.5±0.7		4.32	91.07
	PB-2	52.1+0.3	77.01±0.6		4.30	91.75
	Control	52.4±0.5	75.2±0.5		4.23	92.14
2020-21	PB-1	54.3±0.1	77.5±0.6		4.26	91.47
	PB-2	53.1±0.3	77.4±0.6		4.29	91.68
	Control	52.3±0.4	75.5±0.4		4.21	91.60
2021-22	PB-1	55.1±0.2	82.86±0.4		4.35	91.17
	PB-2	56.1±0.3	79.70±0.5		4.22	92.12
	Control	54.3±0.7	79.70±0.5		4.35	90.53

Table 88. Phenotypic and genetic response in primary and correlated trait

Year	Trait	Phenotypic		Genetic	
2016-17		**PB-1**	**PB-2**	**PB-1**	**PB-2**
	BW 5 wks (g)	10.07	3.68	24.50	24
	FCR 5 wks				
	EP40 (eggs)	-2.31	-0.72	1.44	2.43
2017-18		PB-1	PB-2	PB-1	PB-2
	BW 5 wks (g)	10.04	-3.73	22.09	11.94
	FCR 5 wks				
	EP40 (eggs)	-1.92	-1.06	1.86	2.22
2018-19		**PB-1**	**PB-2**	**PB-1**	**PB-2**
	BW 5 wks (g)	8.33	-2.59	20.65	11.52
	FCR 5 wks				
	EP40 (eggs)	-1.33	-1.20	1.66	1.48
2019-20		**PB-1**	**PB-2**	**PB-1**	**PB-2**
	BW 5 wks (g)	5.67	-2.54	19.11	11.84
	FCR 5 wks				
	EP40 (eggs)	-1.14	-1.62	1.48	0.51
2020-21		**PB-1**	**PB-2**	**PB-1**	**PB-2**
	BW 5 wks (g)	6.03	-3.84	15.59	6.10
	FCR 5 wks				
	EP40 (eggs)	-1.19	-1.89	0.88	0.07
2021-22		**PB-1**	**PB-2**	**PB-1**	**PB-2**
	BW 5 wks (g)	7.09	-0.79	12.71	4.88
	FCR 5 wks				
	EP40 (eggs)	-1.14	-2.01	0.71	-0.23

Random sample broiler test

The commercial cross IBL-80 developed at PAU, Ludhiana performed well at various Random Sample Tests for broilers held in the country since 1979 (Table 89). It held first position for six-week body weight and margin over feed and chick cost in as many as eight Random Sample Tests and second position in as many as six tests when competing with the commercial stocks including those of the private companies. When the comparisons were made amongst the public sector entries alone, IBL-80 held first position in sixteen of the twenty tests and second position in three tests.

Table 89. Performance of IBL-80 in Random sample broiler test

S. No	RST Centres	Year	No. of Entries	6-wks body Wt. (g) (PAU) **		FCR to 6-wks		Dressing %		Overall rank***
01	8th RST Bangalore	1979-80	6	1204	1st	1.85	1st	77.9	1st	1st
02	2nd RST Bombay	1979-80	6	1040	1st	2.1	3rd	72.2	6th	3rd
03	9th RST Bangalore	1980-81	12	1011	1st	2.12	3rd	74.2	3rd	2nd
04	3rd RST Bombay	1980-81	9	1367	1st	2.14	3rd	78.6	1st	2nd
05	1st RST Bhubaneshwar	1980-81	6	1177	1st	2.01	2nd	69.9	4th	1st
06	2nd RST Bhubaneshwar	1981-82	6	1130	1st	2.17	2nd	74.7	1st	1st
07	11th RST Bangalore	1981-82	13	1006	1st	2.15	2nd	74.1	1st	2nd
08	5th RST Bombay	1982-83	8	1605	* 1st	2.23	3rd	78.0	1st	2nd
09	RST Bangalore	1983-84	10	1111	1st	1.98	1st	71.9	1st	1st
10	4th RST Bangalore	1983-84	4	1272	1st	2.26	1st	74.2	1st	1st
11	7th RST Bombay	1984-85	7	1275	1st	2.30	3rd	85.0	2nd	3rd
12	RST Akola	1987-88	4	1081	1st	2.00	4th	81.7	1st	1st
13	13th RST Bangalore	1995-96	6	1060	1st	2.89	5th	67.7	5th	5th
14	12th RST Gurgaon	1995-96	7	1364	2nd	2.29	6th	73.4	6th	6th
15	14th RST Gurgaon	1997-98	7	1492	2nd	2.19	5th	77.5	1st	5th
16	15th RST Gurgaon	1998-99	9	1576	2nd	1.68	4th	76.2	4th	5th
17	17th RST Gurgaon	2000-01	6	1480	1st	1.75	2nd	75.8	1st	2nd
18	18th RST Gurgaon	2001-02	10	1430	2nd	1.64	2nd	71.1	1st	4th
19	19th RST Gurgaon	2002-03	10	1480	1st	1.78	2nd	72.4	9th	1st
20	21st RST Gurgaon	2003-04	8	1588	1st	1.89	3rd	72.7	2nd	4th

* 7-wks body weight ** Position among the public sector entries

*** Position among the overall entries including that of private sector.

7 Odisha University of Agriculture and Technology, Bhubaneswar

AICRP on Poultry for meat, Bhubaneswar centre was sanctioned during the year 1991-92. The primary objective of the project was to develop suitable male and female lines for production of commercial broilers. To start with, IC3 and IR3 population available at the centre were utilized for this purpose. During the year 1994-95, as per the recommendations of the workshop, male and female lines of IBI-91 broiler developed by CARI were procured by this centre for further study and improvement. The male line was studied for a period of five generations after which it was discontinued as per the recommendation of workshop but female line was continued further. From the year 1994-95 till 2001-02, the principal trait of selection was six weeks body weight and subsequently, it was changed to five weeks body weight. The centre is working with CSML and CSFL lines in addition to the native 'Hansli' chicken breed.

Fertility and hatchability

Fertility and hatchability have improved significantly in both male and female lines during the period of study (Table 90). In male line, fertility improved from 75.72% in the initial years to 88.79% in the later generations. Similarly, in female line, fertility improved from an average of 84.94% till the year 2007-08 to 90.24% in the later years. Hatchability on total egg set for the corresponding period is improved from 60.07% to 76.71% in male line whereas in females, it improved from 67.89% to 77.95%. For hatchability on fertile egg set, it improved from 81.04% to 86.38% in male line and from 79.54% to 86.36% in female line.

Performance

Body weights and conformation trairs

The Body weights and conformation traits in male and female lines of broiler parents are presented in Table 91. The six week body weight in CSML ranged from 742 to 1182g over the generations. The corresponding values in CSFL was ranged from 784 to 1147. From 2002-03 onwards, 5 week body weight was considered as primary trait of selection and the data of CSML and CSFL was presented in Table 92. While selection was practiced for these traits in male lines, no effort was made to select for these traits in female line. In spite of this, the correlated response was positive and significant for all the conformation traits in most of the cases, irrespective of whether the selection was carried out for either six weeks body weight or five weeks body weight.

Feed conversion ratio

Feed conversion ratio improved from 2.39 to 2.29 between the years 1994-95 to 2001-02 in the female line when the criterion of selection was 6 weeks body weight. No substantial changes were recorded in feed efficiency in the male line during the period of study. The FCR averaged around 1.99 and 1.96 in males and females respectively during the years 2008-09 to 2019-20 (Table 90).

Mortality

The mortality for the pure lines up to six weeks of age at the centre is summarized in the Table 92.

Male line

The four generations of selection for six weeks body weight brought about an average improvement of 85.04 g in males and 62.75 g in females of male line. The average response per generation for males and females respectively was 0.49° and 0.58° for Breast Angle, 0.22 and 0.15 mm for shank length and 0.17 and 0.33 mm for keel length.

Female line

Body weight at 6 weeks of age was the primary trait of interest from 1994-95 to 2001-02. To derive short term response for 6 weeks body weight and associated traits, data was divided into two four years period i.e. from

Table 90. Trend of fertility, hathability and FCR in siren dam lines (1994-2005)

Year	Strain	Fertility (%)		Hatchability (%)				FCR	
		IBI-91		IBI-91				IBI-91	
		M-line	F-line	TES		FES			
				M-line	F-line	M-line	F-line	M-line	F-line
1994-95		56.87	49.78	44.08	38.34	87.08	76.83	2.28	2.39
1995-96		74.77	69.41	56.54	53.64	75.44	77.30	2.32	2.41
1996-97		74.97	92.97	55.62	87.43	74.75	94.02	2.307	2.40
1997-98		84.33	90.86	71.76	76.07	85.12	83.71	2.308	2.43
1998-99		87.65	87.54	72.37	74.85	82.81	85.31	2.32	2.44
1999-00		-	88.86		36.34		41.25		2.42
2000-01			84.87		61.97		72.20		2.29
2001-02			86.85		67.95		78.22		-
2002-03			92.85		79.26		85.37		1.97
2003-04			88.03		79.82		90.63		1.96
2004-05			91.38		81.20		88.85	1.94	
			SDL		**SDL**		**SDL**	**SDL**	
2005-06			84.25		69.16		81.19	1.92	
2006-07			89.72		69.91		77.59	1.99	
2007-08			91.75		74.60		81.12	1.97	
		CSML	**SDL**	**CSML**	**SDL**	**CSML**	**SDL**	**CSML**	**SDL**
2008-09		75.10	88.15	63.78	73.50	84.92	83.22	2.19	2.13
2009-10		90.48	90.24	76.90	78.04	85.0	86.48	2.12	1.94
2010-11		88.52	89.93	75.30	79.40	85.07	88.16	2.01	1.98
2011-12		91.21	89.07	77.95	80.78	85.47	90.70	2.07	
2012-13		90.60	89.97	81.27	66.57	89.69	73.99	2.05	
2013-14		94.35	93.48	81.55	82.11	86.40	87.80	1.93	
2014-15		90.24	93.86	81.45	81.08	90.25	86.38	1.96	
2015-16		89.86	89.89	69.95	71.46	77.90	79.49	1.93	
2016-17		90.54	90.15	82.98	82.15	91.63	91.13	1.90	
2017-18		89.51	93.76	73.17	82.87	81.69	88.38	1.93	
2018-19		88.12	87.55	77.21	78.61	87.63	89.79	1.91	
2019-20		86.92	86.84	78.99	78.83	90.89	90.77	1.93	
2020-21		ND	ND	ND	ND	ND	ND	ND	
2021-22		ND	ND	ND	ND	ND	ND	ND	

1994-95 to 1997-98 and from 1998-99 to 2001-2002. Three generations of selection from 1994-95 to 1997-98, brought about an average response per generation of 129.17 g in males and 92.87 g in females. The average response during this period in males and females respectively was 1.089° and 0.952° for breast angle, 0.33 mm for shank length and 0.48 mm and 0.26 mm for keel length.

The average response per generation for males and females respectively was 22.87g and 18.64g for 6th week body weight, 0.28° and 0.72° for breast angle, 0.34 mm and 0.22 mm for shank length and 0.27 mm and 0.51 mm for keel length.

Data of all eight generations collected in the female line between the year 1994-95 and 2001-02 were analysed together for evaluating long term response. The average response per generation from seven generations of selection was 46.6 g in male and 27.79 g in females for six weeks body weight, 0.85^0 in males and 0.62^0 in females for breast angle, 0.25 mm for shank length for both the sexes and 0.22 mm in males and 0.27 mm in females for keel length.

The criterion of selection was subsequently changed from six weeks to five weeks. The average response per generation was 13.82 g in males and 6.55 g in females for 5 weeks body weight which is much less as compared to the average response in 6 weeks body weight. The average correlated response for breast angle, shank length and keel length respectively, were 0.32^0, 0.23 mm and 0.24 mm in males and 0.40^0, 0.08 mm and 0.10 mm in females.

Table 91. Trend of body weight and conformation traits in IBI - 91 during the initial generations

Year	Body wt. 6 wks (g)				Breast angle (°)				Shank length (mm)				Keel length (mm)			
	M-Line		F-line		M-Line		F-Line		M-line		F-line		M-line		F-line	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1994-95	928.09	810.47	902.44	838.36	52.53	50.75	51.04	49.93	6.93	6.81	6.79	6.68	7.91	7.71	7.81	7.70
1995-96	1315.95	1094.36	1299.15	1087.48	53.36	51.86	53.61	51.87	7.82	7.22	7.60	7.22	7.91	7.71	7.81	7.70
1996-97	1327.44	1103.90	1317.18	1202.69	54.10	52.25	54.33	52.48	7.86	7.29	7.69	7.25	8.93	8.34	8.74	8.27
1997-98	1334.72	1108.96	1327.01	1109.53	54.42	52.58	54.43	52.90	7.89	7.40	7.87	7.36	8.99	8.39	8.86	8.37
1998-99	1343.92	1116.92	1336.18	1112.54	54.49	53.29	56.64	53.05	8.00	7.51	7.98	7.45	9.02	8.50	9.04	8.43
1999-00			1342.78	1117.53			56.74	53.43			8.03	7.62			9.05	8.45
2000-01			1357.97	1148.39			56.98	54.69			8.75	8.06			9.71	9.19
2001-02			1407.35	1164.40			57.52	55.03			8.88	8.03			9.73	9.90

Table 92. Trend of body weight and conformation traits in IBI - 91 from 2012-13 to 2019-20

Year	Body wt. 5 wks (g)		Breast angle (o)		Shank length (mm)		Keel length (mm)		Mortality % (6 wks)	
	CSML	CSFL	CSML	CSFL	CSML	CSFL	CSML	CSFL	CSML	CSFL
2012-13	1094	1070	63.52	53.23	9.66	8.45	10.63	9.51	5.02	6.71
2013-14	740	784	51.83	51.39	8.25	8.28	8.91	8.79	4.98	6.23
2014-15	1101	999	51.96	52.29	8.43	8.57	8.97	8.96	4.54	4.82
2015-16	1102	1001	51.81	52.04	8.26	8.09	9.20	9.03	4.89	5.20
2016-17	1112	1010	51.31	52.16	8.18	8.14	9.18	9.16	5.06	4.91
2017-18	1105	1006	51.35	51.88	8.19	8.01	9.21	8.94	4.84	4.52
2018-19	1129	1025	52.15	52.06	8.07	8.06	8.63	8.58	4.53	4.82
2019-20	1137	1032	53.05	52.16	8.15	8.11	8.67	8.55	4.09	4.19

The intensity of selection applied averaged over both the sexes ranged from 0.649 to 1.105 during the period 1997-98 to 2003-04 (Table 93). Since response is a function of intensity of selection applied, the observed response as recorded in this study was not unexpected. In order to have a higher intensity of selection, the workshop, therefore, recommended to generate and test more number of individuals in each line which will help in optimizing response in the population under study. This resulted in reducing number of strains in each centre. Although this will help in maximizing response, study will not be conclusive since performance of the lines in cross combination cannot be evaluated. There is a need, therefore, to house at least two lines one male line and other female line at each centre.

Table 93. Trend of selection intensity and mortality in broiler lines

Year		Intensity of selection		Year		Intensity of selection	
	Sex	CSML	CSFL		Sex	CSML	CSFL
2008-09	Male	1.15	1.027	2014-15	Male	1.05	1.13
	Female	1.12	1.054		Female	0.92	0.68
2009-10	Male	1.15	1.031	2015-16	Male	1.13	1.15
	Female	1.12	1.158		Female	0.99	0.92
2010-11	Male	1.11	1.03	2016-17	Male	1.16	1.06
	Female	1.09	1.02		Female	0.81	0.95
2011-12	Male	1.44	1.03	2017-18	Male	0.76	1.16
	Female	1.61	1.006		Female	0.52	0.04
2012-13	Male	1.17	1.03	2018-19	Male	0.49	0.92
	Female				Female	0.58	0.82
2013-14	Male	1.69	1.47	2019-20	Male	0.67	0.97
	Female	0.85	0.41		Female	0.59	0.91

Production traits

The production traits are presented in Table 94. Selection for 6 weeks body weight did not appear to have any significant influence on ASM and this remained more or less same in both the male and female lines under study even when the criterion of selection was changed from 6 to 5 weeks. Egg number, on the other hand, showed improvement and increased from 43.13 egg in 1995-96 to 53.78 eggs up to 40 weeks of age in 2018-19 in female line broiler (Table 94). Selection for 6 or 5 weeks body weight did not appear to have any influence on 32 weeks egg weight. However, it was interesting to note that when selection was carried out on the basis of 5 weeks body weight, the egg weight was somewhat lesser at 32 weeks of age compared to when selection was practiced for 6 weeks body weight.

Random sample Test Report

The performance of the stock developed at the centre has been assessed in Random Sample Tests over the years and has been presented in Table 95. During the year 1994-95, the 6th and 7th week body weight of the commercial broilers was reported to be 1062 and 1370 g with FCR of 2.57 and 2.61. During the year 1997-98, there was significant improvement in the performance of commercial broiler at Random Sample Performance test. The 6th and 7th week body weights were reported to be 1397 and 1797g with FCR of 2.29 and 2.33. Thus, within a period of three years, 6th and 7th week body weight of commercial broiler increased by 335 g and 427 g respectively. FCR also improved by 0.28 both at 6th and 7th week of age and from 1998-99, only pure female lines have been tested at RSBT since male line has been dropped. The performance of the pure dam line studied at the centre for 6 weeks and 7 weeks body weight respectively, was 1186 and 1497 g in the year 1998-99, 1350 and 1701 g in 2001 and 1325 and 1700 in 2002-03. The corresponding values for FCR were 2.88 and 2.98, 2.7 and 2.7 and 1.93 and 2.23. However, 2000-01 onwards, a decline has been observed in 6th and 7th week body weights and also, the trend in FCR is also not consistent.

Table 94. Trend of production traits broiler strains

Year	BW 20 (g)				BW 40 (g)				EP 40 (Nos.)		ASM (d)	
IBI-91												
	M-Line		F-line		M-Line		F-Line					
	M	F	M	F	M	F	M	F	M-line	F-line	ML	FL
1994-95												
1995-96	2522.55	1976.65	2842.77	1991.46	3496.11	2639.95	3552.38	2558.38	40.13	43.13	186	183
1996-97	2293.78	2034.37	2234.31	1885.87	3719.28	3160.68	3739.09	3253.99	41.37	43.87	192	179
1997-98	2349.89	2032.77	2483.30	2112.91	3221.53	2686.56	3239.45	2669.79	40.13	42.17	187	189
1998-99	2863.81	2406.33	2410.13	2146.60	3263.11	2773.05	3295.71	2789.85	40.08	43.60	191	186
1999-00			2482.14	2184.14			3304.47	2824.36		44.29		184
2000-01			2447.96	2274.61			3297.12	2819.79		45.28		183
2001-02			2243.32	2217.63			3304.51	2872.31		47.23		187
2002-03			2456.07	2239.36			3216.10	2754.01		50.14		184
2003-04			2466.01	2219.05			3220.12	2752.09		49.28		187
2004-05			2442.23	2199.56			3238.66	2756.20		EP40 50.91		186
			SDL				SDL			SDL		SDL
2005-06			2445	2208			3242	2791		48.62		183
2006-07			2428	2197			3248	2788		14.71 (EDS-76)		186
2007-08			2035	1803			3156	2692		13.64 (EDS-76)		189
	CSML		CSFL		CSML		CSFL		CSML		CSFL	
2008-09	2077	1850	2095	1959	3092	2704	3148	2714	30.91	37.75	179	175
2009-10	2042	1944	2099	1987	3056	2727	3198	2764	36.29	37.92	182	173
2010-11	2113	1986	2110	1985	3253	2835	3177	2782	40.22	41.33	175	170
2011-12	2130	1900	2110	1945	3002	2795	3186	2747	47.33	49.75	172	171
2012-13	1936		2006		2586		2577		29.17 (HHEP%)	35.64 (HHEP%)	189	185
2013-14	2059		2021		2524		2513		45.64 (HDEP%)	48.18 (HDEP%)	187	180
2014-15	2064		2100		2559		2725		62.38 (HDEP%)	65.41 (HDEP%)	189	184
2015-16	2480		2302		3228		3049		61.39	64.32	184	182

Table 95. Random sample performance test report

Year	Centre	Body weight (g)		Mortality (%)		FCR	
		6th wks	7th wks	6th wks	7th wks	6th wks	7th wks
1994-95		1062	1370			2.57	2.61
1997-98		1397	1797	-	5.66	2.29	2.33
1998-99		1186	1497	6	-	2.88	2.98
2000-01		1350	1710	12	-	2.7	2.7
2002-03		1325	1700	1.3		1.93	2.23
2009-10	33rd RSPT	1304	1780	ND	ND	2.09	2.14
2011-12	36th	1394	1732			2.17	2.30
2014-15		1108	1512			2.37	
2016-17	45th	ND	ND				

8 ICAR-Central Avian Research Institute, Izatnagar (Meat)

The project was initiated at Poultry Research Division, IVRI, Izatnagar by taking three broilers strains viz. IR-1, IC-1 and NH-1 in 1971-72 at experimental Poultry farm of the division. During March-April 1972, four more broiler stocks were imported viz. IR-2, IR-3, IC-2 & IC-3. The project initiated with IC-2, IC-3, IR-2 and IR-3 populations in 1972 and encompassed all the synthetic broiler lines viz. Synthetic populations (SBML-1 and 2), SDL, SML, CSML and CSFL from 1988-89 to 1999-2001. The stocks / lines included in the project and the selection criteria at different years are summarized below:

The CARI centre was initiated in the year 1972-73 with two Cornish and two Rock strains namely, IC-2, IC-3, IR-2 and IR-3 till 1989. IR-1, IC-1 and NH-1 did not yield desired results, therefore, were dropped from project in the year 1980. The synthetic populations were developed by crossing IR-2 and IR-3 strains in the year 1983-84. Some selected crosses were also tested by using Cornish as male and Rocks as female lines during the year 1975-77. Later, in the year 1989-90, white plumaged synthetic sire and dam lines were developed which were used in the project till 2000-01. The coloured plumaged synthetic sire and dam lines developed in the year 1994-95 are still continuing in the project. The performance profile of different stocks under the project at different time period is summarized below:

Achievements

Means of fertility and hatchability (FES) %, ASM and egg production up to 40-weeks in IC-2, IC-3, IR-2 and IR-3 strains are presented in Table 96. Range of corresponding traits was from 73.1% to 92.3%, 66.7% to 85.6%, 166 to 185 days and 33 to 51 eggs respectively in Cornish strain. Corresponding ranges in Rock strains were 79.6% to 94.5%, 65.9 to 87.7%, 165 to 189 days and 32 to 58 eggs respectively. Phenotypic response for AFE, egg production to 40 weeks, fertility and hatchability were 1.31 day, 0.72 egg, 1.47% and 1.19% per generation respectively.

Table 96. Reproductive performance of different stocks w.e.f. 1975-76 to 1988-89

Year	75-76	76-77	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	88-89
Fertility (%)													
IC-2	82.6	90.2	79.1	73.1	76.3	88.5	86.1	85.6	87.0	87.9	-	-	
IC-3	92.3	88.3	82.2	79.6	85.6	82.0	90.1	88.9	81.0	86.5	83.6	82.1	85.2
IR-2	86.8	91.6	83.4	80.9	88.2	90.6	92.3	94.5	90.1	82.9	-	-	
IR-3	85.3	84.0	82.2	79.6	85.6	90.9	87.7	87.6	84.3	83.0	90.0	89.3	90.8
Hatchability (% FES)													
IC-2	75.9	66.7	79.5	76.5	72.3	71.4	74.2	65.6	77.9	84.8	-	-	
IC-3	72.4	66.7	80.3	79.9	65.9	69.1	78.8	74.7	75.7	85.6	85.6	75.5	74.0
IR-2	70.1	77.7	85.3	74.4	57.8	84.4	79.8	73.6	81.6	87.7	-	-	
IR-3	68.1	65.9	84.5	71.4	55.6	83.2	76.5	73.3	74.0	84.9	82.5	83.0	80.1
ASM (days)													
IC-2	177	170	185	178	175	177	170	176	176				
IC-3	178	180	185	183	179	166	166	175	173	172	170	-	-
IR-2	172	189	185	185	186	180	180	180	180				
IR-3	165	189	190	186	187	171	171	178	175	173	173	-	170
Egg Production 40 wks (Nos.)													
IC-2	49	42	41	36	51	44	41	46	46	-	-	-	-
IC-3	44	35	42	33	46	40	38	44	48	45	45	-	-
IR-2	50	32	44	32	32	32	31	40	40	-	-	-	
IR-3	51	35	39	33	32	35	39	51	54	55	58	-	51

Growth performance

Body weight at 8 weeks in IC-2, IC-3, IR-2 and IR-3 averaged 984.6 g, 1102.92 g, 926.09 g and 978 g respectively (Table 97). Body weight at 8-weeks was recorded in IC-3 and IR-3 till 1986-87 and was 1495 and 1325 g respectively, thus showing a gain of 35% and 26%, respectively over the initial weight in 1975-76 i.e. in a period of 11 years. The six weeks body weight was recorded from 1982-83 to 1988-89 in IC-3 and IR-3 strains. Mean six weeks body weight in 1982-83 in IC-3 and IR-3 were 760 and 703 g whereas corresponding weights in 1988-89 were 950 and 905g. Average body weight at 40 weeks over the years (1975-75 to 1983-84) were 3026 g, 3044 g, 2669 g and 3015 g in IC-2, IC-3, IR-2 and IR-3 strains respectively. Feed conversion ratio (0-8 weeks) ranged between 2.5 to 2.73 and mortality (0-8 weeks) ranged between 1.0 and 18.0% in these strains during 1975 to 1987. Phenotypic response for 8 weeks body weight and FE (0-8 weeks) were 22.0 g and 0.004 per generation. Pooled estimates of heritability for 8-weeks body weight from 1975-87 were 0.12±0.004 and 0.25±0.01 in IC-3 and IR-3 males and 0.25±0.001 and 0.34±0.04 in IC-3 and IR3 females, respectively. Corresponding estimates for 6 weeks body weight were 0.22, 0.24, 0.35 and 0.32 respectively. Pooled genetic correlations between 6 and 8-weeks body weight ranged from 0.73 to 0.90.

Table 97. Growth performance of different strains

Year	75-76	76-77	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	88-89
Body weight at 6 weeks (g)													
IC-2	-	-	-	-	-	-	-	-	-	-	-	-	-
IC-3	-	-	-	-	-	-	-	760	615	564	706	962	950
IR-2	-	-	-	-	-	-	-	-	-	-	-	-	-
IR-3	-	-	-	-	-	-	-	703	580	546	626	859	905
Body weight at 8 weeks (g)													
IC-2	1091	952	1006	1020	992	1008	897	1067	928	885	-	-	-
IC-3	1082	991	1022	1056	1011	1075	968	1150	1045	1032	1344	1459	-
IR-2	1037	954	956	788	676	981	875	1040	975	944	961	-	
IR-3	1051	1009	982	788	657	979	916	1046	972	895	1116	1325	
Body weight at 40 weeks (g)													
IC-2	2414	3026	2960	2980	2472	2978	3640	3420	3350				
IC-3	2423	2929	3065	3100	2312	3060	3680	3454	3380				
IR-2	2309	2771	2983	3121	2464	299	3520	3325	3230				
IR-3	2379	2785	3637	2991	2492	3308	3350	3139	3060				
FCR 0-8 weeks													
IC-2	2.62	2.61	2.59	2.60	2.6	2.70	2.75	2.65	2.70	-	-	-	-
IC-3	2.68	2.67	2.58	2.59	2.63	2.58	2.65	2.6	2.67	2.69	2.65	2.50	-
IR-2	2.52	2.66	2.61	2.65	2.94	2.55	2.68	2.66	2.70	2.72	2.71	-	-
IR-3	2.6	2.6	2.63	2.66	2.98	2.70	2.71	2.65	2.70	2.73	2.67	2.53	-

Phase –II

The research work under meat project at Central Avian Research Institute is aimed at development of high-yielding broiler sire and dam lines for enhancing the broiler production. The meat project was initiated with modest infrastructure facilities and small size of base population. Construction of new sheds/brooder houses, modifications of old sheds etc. were taken up from time to time. Conventional system is being followed for management of birds at different stages of their life. The long-term selection and breeding strategies are being followed for achieving the goal. Starting with Cornish, Rock and New Hampshire stocks in 1972, the synthetic broiler populations were developed in 1990 by selection for economic traits and by combining the genes of modern representatives of broiler stocks. The flocks are kept in open houses with minimum use of vaccines and medication. While developing such high yielding stock, the adaptability of these stocks to harsh tropical climate is also given due consideration. The desirable genes from elite modern stocks were incorporated in the pure male and female broiler lines developed at this centre through judicious crossbreeding in order to optimize the sire and dam characteristics. The base populations were established after two generations of crossbreeding and two generations of random mating.

Synthetic Broiler Sire and Dam lines

The concerted research efforts for last several years have resulted into development of two specialized synthetic dam lines *viz.* white plumaged synthetic broiler dam line (SDL), and coloured synthetic female line (CSFL) with coloured plumage and two specialized synthetic sire lines *viz.* white plumaged synthetic male line (SML) and coloured synthetic male line with coloured plumage (CSML). The white male line was nicking best with white female lines and coloured male line with coloured female line for production of commercials.

The stock with multicoloured plumage with excellent growth rate and adaptability to tropical climate was developed as male line broiler stock keeping in view the high demand of coloured broilers. The stock is undergoing long-term selection for high juvenile body weight for further improvement. Development of CSFL was also initiated in order to complement the coloured synthetic male line. The line was developed by long-term selection for high juvenile body weight and mild culling against lower egg production traits. The salient features of the line are multicoloured plumage with good juvenile and reproductive traits and better adaptation to tropical climate. A random bred control population was also maintained since 1978 for comparing the various lines under selection in order to estimate the environmental deviations.

Achievements

The selection criterion in CSML and CSFL was primarily the higher body weight at five weeks. However, some mild selection was also imposed for better egg production up to 40 weeks of age in CSFL. Initially, approximately 10% of males and 60% females were selected on the basis of higher five weeks body weight. Finally, top 45 males and 270 females were selected as breeders in both the lines (CSFL and CSML). Standard management practices were followed from 0 to 6 weeks of age. Standard starter ration was provided during the period. Growing birds were fed on grower ration on a suitable restricted feeding programme up to 21 weeks of age, thereafter, the breeder ration was provided to selected birds. After onset of laying, the females were put in cages for recording the egg production. Vaccination programme was carried out against Marek's, Ranikhet and IBD diseases.

Synthetic Broiler Lines (1989-2001)

Synthetic broiler sire and dam lines were developed from synthetic base population.

Synthetic Male line

Synthetic base population for broiler chicken was developed from four leading commercial broiler stocks and two pure broiler lines. In first year, 2-way crosses (S-0) and in second year, 4-way crosses (S-1) were raised. Random mating was followed in third year (S-3) and pedigreed mating (Avoiding full sibs) in fourth year (S-4). The two sire lines produced initially were named as SML-1 and SML-2. SML-1 was coloured plumaged and SML-2, which was also called as white synthetic male line (WSML) had white plumage. SML-2 had two sub-lines i.e. growth line (GL) and index line (IL). These sub-lines were further named as SG and SF lines respectively. These lines were included in synthetic sire lines. Mean body weights at 6, 8, 24 and 40 weeks in males of base population were 1332, 2211, 2800 and 4100 g, respectively. Corresponding weights in females were 1104, 1828, 2300 and 3100 g respectively. Further, fertility, hatchability, egg production at 40 weeks, ASM were 85%, 85%, 130-140 eggs and 160 days respectively.

The male synthetic broiler line (SML-2) developed in the year 1989-90 remained in the project till 2000-01. White plumaged SML-2 had two sub-lines SG (GL) and SF (IL), which differed in their selection criteria.

Performance profile of Growth Line

Performance of SG line for 11 generations of selection is presented in Table 98. Body weights at 4, 6 and 7 weeks of age ranged from 658 to 990 g, 1267 to 1790 g and 1590 to 2150 g, respectively in different years. FCR (4-6 weeks) over the years ranged from 2.32 to 2.63. Genetic and phenotypic gains for most of the traits were significant and in desired directions.

Table 98. Phenotypic and genetic responses for different broiler traits in combined progeny in growth line in 11 generation of selection

Traits	Gen.	0	1	2	3	4	5	6	7	8	9	10	11	R (b)
	year	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	
BW 4, wks	X	660	658	673	707	755	835	815	888	900	984	990	812	28.60**
	DC	131	162	122	158	171	245	210	342	293	394	344	258	23.06**
BW 6, wks	X	1268	1267	1310	1353	1362	1572	1559	1531	1540	1730	1790	1461	39.16**
	DC	152	311	174	334	311	348	355	406	500	648	792	536	42.79**
BW 7, wks	X	1827	1590	1756	1706	1900	1950	1925	1910	1921	2144	2150	1770	28.70*
	DC	342	290	326	341	570	609	483	495	552	824	841	541	39.30**
BA 6, wks	X	62.7	63.4	61.7	60	63.4	65.3	65.1	64.6	64.6	66.4	65.1	-	0.34**
	DC	3.89	4.87	2.51	1.99	6.18	4	4.12	5	5.58	6.04	6.12	-	0.15
SL 6, wks	X	6.67	6.55	7.04	7.42	7.47	7.81	7.78	7.7	7.63	7.43	7.3	-	0.07*
	DC	0.65	0.32	0.04	0.57	0.61	0.69	0.55	1.3	1.28	1.1	1	-	0.08**
KL 6, wks	X	8.74	8.34	8.98	8.69	8.75	8.92	8.88	8.71	8.69	8.59	8.7	-	0
	DC	0.51	0.41	0.34	0.78	0.95	0.32	0.25	0.2	0.34	0.41	0.38	-	-0.01
WG (4-6 wks)	X	608	631	647	645	608	737	744	645	634	745	800	624	8.55
	DC	21	149	62	172	142	140	144	67	202	106	450	248	14.56**
FC (4-6 wks)	X	1566	1481	1613	1556	1458	1728	1747	1528	1669	1730	1930	-	24.54*
	DC	-42	172	95	459	260	187	211	21	379	180	765	-	19
FCR (4-6 wks)	X	2.57	2.43	2.5	2.41	2.4	2.35	2.35	2.37	2.63	2.32	2.41	-	0
	DC	-0.17	-0.29	-0.1	0.07	-0.17	-0.2	-0.21	0.23	-0.35	-0.66	-0.92	-	-0.03
FE (4-6 wks)	X	0.38	0.42	0.4	0.41	0.41	0.43	0.42	0.42	0.38	0.43	0.41	-	0
	DC	0.02	0.04	-0.2	-0.03	0.02	0.05	0.03	0.04	0.05	0.03	0.11	-	0.01

Performance profile of Index Line (SF)

The index line, which was selected on the basis of better-feed efficiency from 4-6 weeks by using a linear index also, has undergone selection for 11 generations. Overall performance of SF line is presented in Table 99. Body weights at 4, 6 and 7-weeks of age ranged from 652 to 976 g, 1216 to 1793 g and 1580 to 2145 g, respectively in different years. FCR (4-6 weeks) over the years ranged from 2.16 to 2.57. Genetic and phenotypic gains for most of the traits were significant and in desired directions.

Table 99. Phenotypic and genetic responses for different broiler traits in combined progeny in index line in 11 generation of selection

Traits	Gen	0	1	2	3	4	5	6	7	8	9	10	11	R (b)
	Year	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	
BW 4, wks	X	660	652	667	692	726	767	757	814	840	976	970	686	22.05**
	DC	131	156	116	143	142	177	152	268	233	386	324	132	16.50*
BW 6, wks	X	1268	1256	1310	1299	1340	1501	1483	1420	1444	1793	1710	1216	27.42*
	DC	152	300	174	280	289	313	279	304	404	711	712	286	30.83**
BW 7, wks	X	1827	1616	1775	1679	1863	1921	1891	1856	1860	2145	2100	1580	17.77
	DC	342	316	345	314	533	58	449	441	491	825	791	350	30.15
BA 6, wks	X	62.71	62.04	61.64	59.5	63.12	64.88	64.65	64.52	64.48	66.05	65.59	-	0.39**
	DC	3.89	3.55	2.46	1.5	5.86	3.62	3.65	4.9	5.47	5.76	7.59	-	0.22*
SL 6, wks	X	6.67	6.59	7	7.48	7.46	7.7	7.63	7.61	7.48	7.42	7.62	-	0.76**
	DC	0.65	0.36	0.36	0.63	0.6	0.58	0.4	1.21	1.13	1.66	1.32	-	0.89**
KL 6, wks	X	8.74	8.38	8.89	8.69	8.69	8.86	8.78	8.71	8.61	8.46	8.32	-	-0.02
	DC	0.51	0.41	0.25	0.78	0.89	0.26	0.15	0.2	0.26	0.28	0.00	-	-0.03
WG (4-6 wks)	X	608	628	641	606	616	734	726	616	605	816	740	578	6.61
	DC	21	146	56	133	150	137	126	38	173	177	390	202	12.62**
FC (4-6 wks)	X	1566	1466	1602	1389	1406	1652	1625	1386	1508	1764	1650	1318	1.99
	DC	-42	157	84	292	208	111	89	-121	218	214	485	292	12.06
FCR (4-6 wks)	X	2.57	2.33	2.5	2.29	2.28	2.25	2.24	2.26	2.56	2.16	2.22	2.32	-0.02
	DC	-0.17	-0.39	-0.1	-0.25	-0.29	-0.3	-0.32	-0.34	-0.42	-0.82	-1.11	-0.41	-0.04
FE (4-6 wks.)	X	0.38	0.42	0.4	0.45	0.44	0.44	0.45	0.45	0.4	0.46	0.44	0.43	0.003
	DC	0.02	0.04	0.02	0.01	0.05	0.06	0.06	0.07	0.07	0.06	0.14	0.07	0.006

Synthetic Female Line

Six elite crosses and pure dam line were used for developing the base population of synthetic broiler dam line. Same mating procedure, as was followed in male line development, was followed. Means of body weight at 4, 6 and 8 weeks (combined sex), ASM, egg production to 30 weeks age (%) were 659 g, 1215 g, 1849 g, 162 days and 72 eggs respectively. The synthetic dam line developed in the project was named as synthetic broiler dam line (SDL), which was white plumaged.

Synthetic Broiler Dam Line (SDL)

White plumaged synthetic broiler dam line was developed in 1989-90 and remained in the project till 2000-01. Performance of SDL is presented in Tables 100 and 101. Means for ASM, EW 40 wks, EP-40 wks, Fertility and hatchability over the years ranged from 163 to 188 days, 56.2 to 61.2 g, 43 to 61 eggs, 75.4 to 85.9% and 73.3 to 84.5%, respectively (Table 100). Genetic and phenotypic responses for reproductive traits were low. Body weights at 4, 6 and 24 weeks of age ranged from 551 to 880, 1055 to 1436 and 2440 to 3217 g, respectively (Table 101). Genetic and phenotypic responses were positive and significant for 4 and 6 weeks weights.

Table 100. Mean reproductive performance of SDL and deviation from control in different generations

Trait	Gen	0	1	2	3	4	5	6	7	8	9	10	11	Reg
	Year	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	
ASM, days	Mean	163	168	188	186	184	178	165	165	166	168	168	167	-0.93
	DC	0	1	1	3	2	-1	-5	-6	-5	-3	-4	-4	-0.72
EW 40, wks	Mean	56.2	58.7	68.8	60.5	60	59.2	59.2	59.9	60.8	60.9	61.2	60.6	0.07
	DC	0	1	9.9	2.2	2	1.5	1.1	2.2	2.3	2.5	2.6	1.5	-0.04
EP 40, wks	Mean	50	46	43.4	44.5	45.5	59.2	59.9	59.7	60.5	60.9	61.2	61.4	1.51
	GG	0	1.5	1.2	1.8	2.6	3.4	4.8	6.8	7.2	8.5	9.2	1.5	1.5
Fertility (%)	Mean	85	84.6	85.2	75.4	75.9	78.9	83.78	82.9	83.2	83.1	85.9	81	0.15
	DC	0	-1	0.1	-2.1	-3.34	-1.09	-1.2	-1.0	-0.67	-0.8	1.9	13	0.11
Hatcha-bility (%)	Mean	84.5	74.6	83.6	73.3	71.7	75.8	74.1	74.7	75.1	79.2	81.3	84	-0.16
	DC	0	-4.3	-2.7	-7.1	-0.3	1.1	-7.1	-3.8	-3.5	-4.7	-2.6	0	-0.16

Table 101. Means, phenotypic and genetic responses of body weights at different ages in SDL in different generations

Gen.	0	1	2	3	4	5	6	7	8	9	10	11	12	Reg
	Year	89-90	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	
BW 4	551	568	577	592	537	649	653	692	777	767	785	802	880	27.60**
DC	0	-5	58	60	24	104	108	125	175	178	160	112	233	16.86**
BW 6	1055	1078	1152	1126	1186	1180	1206	1339	1416	1397	1434	1436	1341	33.33**
DC	0	17	125	108	65	137	164	261	250	264	240	216	329	24.13**
BW 24	2440	3043	2545	3099	3010	2862	2787	2798	2812	2795	2835	3217	2876	17.99
DC	0	38	82	84	105	22	-21	-22	19	14	24	298	95	6.66

Coloured Synthetic Male Line (CSML)

Performance profile of CSML over the years is presented in Table 102. Fertility and hatchability percentages ranged from 68.0 to 79.3 and 66.0 to 78.0, respectively. Body weight at 4, 5 and 6-weeks ranged from 675 to 926 g, 944 to 1222 g and 1239 to 1640 g respectively.

Table 102. Production performance of Coloured Synthetic Male Line (CSML)

Gen.	BW 4 (g)	BW 5 (g)	BW 6 (g)
0	681.55	-	1239.62
1	675.19	-	1368.31
2	739.06	-	1417.29
3	781.98	-	1422.23
4	859.59	-	1425.89
5	917.00	-	1616.00
6	926.00	-	1640.00
7	-	944.00	-
8	-	1002.00	-
9	-	1038.13	-
10		1054.65	
11		1068.77	
12		1075.88	
13		1082.72	

Gen.	BW 4 (g)	BW 5 (g)	BW 6 (g)
14		1096.59	1255
15		1102.95	1271
16		1148.78	
17		1163	
18		1174.80	
19		1187.61	
20		1194.69	
21		1210.80	
22		1222.63	
23		1220.00	
24		ND	
25		ND	
26		1198	
27		1243	

Coloured Synthetic Female Line (CSFL)

Growth, production and reproductive performance of CSFL over the years is presented in Tables 103-104. Fertility and hatchability percentages ranged from 66.0 to 91.7% and 73.0 to 94.5% respectively (Table 103). Fertility and hatchability, though exhibited fluctuating trends, were within acceptable limits. The average body weight at 4, 5 and 6-weeks was 716.7, 1106.0 and 1320.9 g respectively (Table 108). ASM, EP-40 weeks and EW-40 weeks over the years averaged around 169 days, 61 eggs and 61.75 g respectively (Table 104). Both EP-40 and EW-40 witnessed an increase over the years.

Table 103. Trend of reproductive and growth performance in CSFL

Gen.	Fertility (%)	Hatchability FES (%)	BW 4, wks (g)	BW 5, wks (g)	BW 6, wks (g)
0	85.0	78.0	580.27	-	1278
1	74.0	77.0	651.4	-	1294
2	74.0	79.0	654.89	-	1318
3	83.0	75.0	647.1	-	1327
4	87.0	86.0	784.2	-	1351
5	86.5	82.6	851.0	-	1443
6	68.1	73.0	848.0	-	1453
7	73.0	83.0	-	928.0	-
8	78.7	81.8	-	957.0	-
9	79.8	81.2	-	1020	-
10	78.31	89.03		1040	
11	79.75	87.52		1056	
12	83.84	89.08		1067	
13	83.47	85.09		1074	
14	86.09	89.06		1085	1205
15	82.10	85.30		1092	1219
16	81.94	84.74		1135	
17	82.01	85.30		1148	
18	82.04	87.06		1161	
19	82.01	89.98		1175	
20	87.67	90.56		1189	
21	91.67	92.82		1196.	
22	88.99	91.01		1209.	
23	86.58	94.57		1208.	
24	86.65	88.91		ND	
25	ND	ND		ND	
26	66.00	88.95		1012	
27	72.91	89.98		1262	

Table 104. Production and reproduction performance of Synthetic Female Lines

Gen.	ASM (days)	EP40 wks (Nos.)	EW 40 wks (g)
0	163	50	56.2
1	168	46	58.7
2	188	43	68.8
3	186	45	60.5
4	184	46	60.0
5	178	59	59.2
6	165	60	59.9
7	165	61	59.9
8	166	61	60.8
9	168	61	60.9
10	168	61	61.2
11	167	61	59.2
12	155	60	63.4
13	154	61	65.6
14	156	62	63.9
15	171	62	59.8
16	161	64	60.12
17	160	65	60.31
18	160	63	60.40
19	165	64	60.96
20	168	64	58.60
21	166	67	59.80
22	165	66	62.00
23	168	65.80	61.69
24	169	66.0	61.84
25	168.22	70.60	63.79
26	179.30	65.80	66.96
27	176.57	66.68	67.07
28	176.98	67.67	ND
29	176.50	68.20	63.77
30	178.20	68.30	67.19
31	ND	59 to 64	59 to 62

Note: The synthetic female line up to 2000-01 was SDL and thereafter, CSFL

Performance of CARIBRO-Dhanraja in RSPPT

The pure male and female lines *viz.* CSFL and CSML were crossed to produce CARIBRO-Dhanraja. The performance of CARIBRO-Dhanraja at different centres of RSPPT from 1998-2002 is summarized in Table 105. The stock has performed exceedingly well in competition with the stock of large private and Govt. hatcheries and secured high ranks in different RSPPT at different centres. The stock has given the best performance during the year 1998 at Bangalore centre where it attained the body weight at 6 and 7-weeks as 1695 g and 2127 g, respectively. In the 19^{th} RSPPT at Gurgaon centre (2001-02), CARIBRO-Dhanraja secured II position with excellent FCR and livability (Table 106).

Table 105. Performance of CARIBRO-Dhanraja over the years at RSPPT Centres

Year/ Centre	BW 6 (g)	BW 7 (g)	Livability (0-7 wks) %	FCR (0-6 wks)	FCR (0-6 wks)	Dressing (7- wks) %	Receipt (Rs.)	
							6 wks	7 wks
1998/M	1365	1798	98	1.80	1.93	82.3	33.66	42.12
1998/G	1580	1984	92	1.71	1.95	74.8	30.45	34.23
1998/Ba	1695	2127	94	2.03	2.08	76.8	31.82	38.47
1999/G	1418	1948	99	1.87	1.89	73.1	27.70	38.40
1999/Ba	1472	1854	99	2.05	2.11	72.6	32.10	39.46
2000/G	1430	1836	99	1.87	2.14	73.1	19.46	20.00
2001/M	1361	1595	99	2.14	2.32	79.5	24.25	25.99
2001/Ba	1458	1887	93	2.21	2.31	74.9	19.63	23.64
2002/ G	1430	1875	99	1.78	2.01	71.0	28.07	33.20
2004/G	1060	1420	94	2.08	2.21	68.7	NA	NA

Table 106. Rank of CARI-Commercial stocks over the years at different centre

Year	Test Centre	Stock	Rank
1997-98	Gurgaon	CARIBRO-91	II
		CARBRO-Multicoloured	III
		CARIBRO-Naked neck	II
1998-99	Bangalore	CARIBRO-91	III
		CARIBRO-Naked Neck	IV
		CARIBRO-Coloured	II
	Gurgaon	CARIBRO-91	VII
		CARIBRO-Coloured	V
		CARIBRO-Naked Neck	VI
	Mumbai	CARI-Coloured	V
1999-2000	Gurgaon	CARIBRO-Naked Neck	II
		CARIBRO-91	I
		CARIBRO-Coloured	II
	Mumbai	CARIBRO-Naked Neck	IV
2000-01	Bhubaneswar	CARIBRO-91	III
	Bangalore	CARIBRO-91	III
	Gurgaon	CARIBRO-Naked Neck	III
		CARIBRO-Coloured	V
		CARIBRO-91	IV
2001-02	Bangalore	CARIBRO-Vishal	II
		CARIBRO-Dhanraja	III
	Gurgaon	CARIBRO-Tropicana	III
		CARIBRO-Dhanraja	II
	Mumbai	CARIBRO-Naked Neck	IV
2003-04	Gurgaon	CARIBRO-Vishal	V
		CARIBRO-Dhanraja	VII

9 Nanaji Deshmukh Veterinary Sciences University, Jabalpur

All India Coordinated Research Project on Poultry Breeding was initiated by ICAR in different agroclimatic zones of the country. The project located at JNKVV, Jabalpur (M.P.), sanctioned during 1970-71, started as layer project to evaluate White Leghorn strains *viz.* IWM, IWN, IWP, IWK, IWL as pure lines to improve egg production. The preliminary work of development of the physical facilities took considerable time and actual work of evaluation of germplasm at this centre started in the year 1973-74. Simultaneously, cross performances of the inter strain crosses were also tested. Performance of the strains was evaluated up to VII plan. Fourteen generations of selection and diallel crossing using four White leghorn strain (IWM, IWN, IWP, IWK) resulted in development of best hybrid MXN, "*Jawahar 260*" commercial layer bird. The IWM strain was identified as best male strain which nicked well with IWN female strain.

Also, a small population of chicken (1975) having sex linked recessive dwarf gene were introgressed in White leghorn genome and two egg type lines *Narmada-XL* and *Krishna-J* were developed. During 1983-85, a pilot study for utilization of sex linked recessive dwarfing gene (dw) was carried out in the production of commercial broiler chicks. During the years 1991-92 to 1994-95, studies on White leghorn strain and dwarf broiler dam line were continued. Dwarf broiler breeder dam line under intra population selection was cross tested to produce commercial broiler chicks for tropical adaptation.

During XI plan period, as the target with respect to introgression of dwarf gene into broiler genome was achieved, this centre was modified as *Rural Poultry Centre* and assigned the programme activity to work on development of new varieties suitable for rural poultry by utilizing local native germplasm *viz.* Kadaknath, Jabalpur colour population CSML and colour dwarf population. After preliminary survey, native fowl Kadaknath was procured and evaluated. Improved chicken germplasm Jabalpur colour evaluated and improved by selection and a direct cross was produced. The males were utilized for terminal cross development (location-specific germplasm). Since its inception, this centre has made significant progress in developing high yielding commercial layer bird, dwarf broiler breeder dams, commercial broilers from dwarf broiler dams and colour chicken variety for rural poultry production.

Phase-I

1970-71 : Initially, six indigenous strains housed and evaluated in 1970-71. In 1971-72 another 3 exotic strains, IWN, IWP & IWO were introduced. During 1972-78, IWK, IWN and IWP from Hyderabad and IWM & IWL from Mathura were added. The populations were evaluated for phenotypic performance and genetic architecture without selection continued till 1978.

Phase-II

From V Plan onwards the target to produce 220 eggs in 500 days of age was fixed subsequently modified to 235 eggs in VI plan and 250 eggs in VII plan. The last mandate of 250 eggs was achieved in VII plan period as commercial egg production increased from 215 to 256 eggs of good size.

Phase-III

In view of diversification of studies in international scenario, ICAR initiated studies on sex linked dwarfing gene (dw) under broiler genome with the objectives:

i. To study the performance of dwarf broiler breeder dam line under intra-population selection and cross testing to produce commercial broiler.

ii. Ancillary studies on feed efficiency traits, tropical adaptation and related traits with dwarf dam lines.

Two dwarf bodied dam population DBG and DBE were maintained and evaluated and these lines were directly crossed with normal bodied broiler sire to produce commercial broiler chicks. Target modified "Utilization of sex linked gene in broiler genome for development of dwarf broiler dams" with main mandate during IX & X Plan

i. To maintain single source pure bred dwarf broiler dam population.

ii. Generation of cross bred dwarf for evaluation of dam line traits.

iii. Production of normal bodied commercial broiler chicks for evaluation of growth.

As the target with respect to dwarf gene under broiler genome was achieved, this centre changed from broiler centre to Rural Poultry centre with objective to develop suitable colour bird for rural poultry production during XI^{th} Plan.

Strains/Breeds maintained at the centre

Layer: Initially, six white leghorn strains *viz*. IWK, IWL, IWM, IWN, IWO, and IWP were allotted to Jabalpur centre. In due course of time, IWL and IWO strains were dropped. As the target was achieved in VII plan period, this centre was instructed to initiate studies on sex linked dwarfing (dw) gene in broiler genome. Therefore, these lines were not conserved in the centre further.

Dwarf broiler dam: In phase III, plan VIII , centre maintained dwarf broiler breeder dam line *viz.* DBG and DBE lines. Under XI plan period, DBG and DBE sub-populations were pooled and a single source pure bred dwarf broiler dam population was maintained and studied. Three normal bodied dam lines procured from other centres were utilized to generate crossbred dwarf dams. Sample of broiler sire line was also obtained and maintained. A colour population carrying dwarf gene (coloured dwarf broiler breeder dam) line was also maintained and studied. So, a single source dwarf broiler breeder dam in white and in coloured plumage were maintained and evaluated.

Rural poultry: As the target with respect to dwarf gene was achieved, centre was converted into a rural poultry centre with the objective to develop suitable colour bird for rural poultry. During this period, Jabalpur colour, (Normal colour bird, improved broiler germplasm) local native chicken, Kadaknath pure bred population were the main parental lines. At present, crossbred Kadaknath (50%) and Narmadanidhi (developed new colour chicken variety) are maintained in the centre in addition to the unpedigreed sample size population of CSFL line, M1 and M2 lines.

Achievements

Layer

The technical programme revolves around three main objectives, namely to evaluate allotted strains as purebreds, to follow suggested breeding technique to improve egg number and to identify strain crosses for egg production. The purebred means over years deviated as under with significant increase in egg number to 280 days of age (Table 107).

Table 107. Mean egg production up to 280 days in White Leghorn pure lines

Strain	1973-74	1986-87	Regression coeff.
IWK	62.3	84.4	2.9±0.71**
IWM	62.9	86.2	1.9±0.57**
IWN	63.9	88.5	2.6±0.45
IWP	65.8	78.2	2.1±0.47**
Control	66.9 (78-79)	71.0	$1.4±1.43^{NS}$

The change in egg number was accompanied by significant decline in age at sexual maturity and non–significant decrease in egg weight. The body weights, fertility and hatchability status showed little deviation (Table 108).

Table 108. Yearly phenotypic regression on generation means

Direct response	IWK	IWM	IWN	IWP	Control
EP 40 wks (Nos)	1.69	1.2*	1.93*	1.49*	1.68
Correlated response	IWK	IWM	IWN	IWP	Control
Sexual maturity	-1.62*	-1.48	-1.63*	-1.83*	-1.21
BW 20, wks (g)	16.1	2.9	6.5	3.70	-
BW 40, wks (g)	13.6*	-12.33	1.1	-3.72	-
EW 40, wks (g)	-0.36	-0.16	-0.14	-0.17	-
Fertility (%)	-3.5	0.9	-1.7	-1.02	-
Hatchability (%)	-0.2	24	0.6	0.4	-

The comparative performance of all the four strains and control for growth (20 wks body wt, 40 wks body wt), reproduction (age at sexual maturity) and production (egg production up to 280 days, average egg weight) traits from the years 1973-74 to 1984-85 is presented in Table 109. Based on the trend, 20 wks body wt. was declining over the years for all the strains except IWN while 40 wks body wt. was declining in the strains IWM, IWN and IWP. Due to the effects of selection, age at sexual maturity was decreasing over the years for all the strains except control. Egg production up to 280 days was on the rise for all the lines while average egg weight was declining over the years.

Table 109. Comparative Performance of Various Strains in Different Traits

Strains	Year	BW 20 (g)	BW 40 (g)	ASM	EW 40 (g)	EP 40 (Nos.)
IWK	1973-74	1442	1498	180.3	59.3	62.3
	1974-75	1149	1430	186.8	58.7	65.3
	1975-76	1043	1555	195.2	56.2	52.6
	1976-77	1192	1660	161.7	56.4	59.8
	1977-78	930	1590	188.8	63.1	59.8
	1978-79	1023	1605	178.0	58.0	64.4
	1979-80	1143	1619	171.5	56.3	64.7
	1980-81	1005	1650	177.6	59.9	62.5
	1981-82	1182	1684	168.9	59.1	74.1
	1982-83	1122	1665	168.7	55.4	73.7
	1983-84	1068	1587	171.6	54.6	75.2
	1984-85	1012	1625	168.9	53.6	83.2
	b ± S.E.	-16.11 ± 10.4	13.62 ±	-1.62 ± 0.70	-0.36 ± 0.20	+1.69 ± 0.49
IWM	1973-74	1066	1582	170.3	53.9	67.9
	1974-75	1169	1485	174.6	52.8	80.2
	1975-76	111	1636	182.0	53.1	69.8
	1976-77	1237	1632	157.0	50.5	78.8
	1977-78	935	1687	182.2	59.6	70.2
	1978-79	1041	1572	168.3	54.0	75.2
	1979-80	1160	1559	162.1	52.6	72.9
	1980-81	1064	1508	164.3	55.0	74.3
	1981-82	1209	1544	159.0	54.4	78.5
	1982-83	1214	1556	154.4	55.5	87.8
	1983-84	1072	1419	162.4	51.5	80.0
	1984-85	971	1458	163.8	49.0	85.9
	b ± S.E.	-2.92 ± 8.46	-12.33 ± 5.55	-1.48 ± 0.65	-0.16 ± 0.23	+1.19 ± 0.41

Strains	Year	BW 20 (g)	BW 40 (g)	ASM	EW 40 (g)	EP 40 (Nos.)
IWN	1973-74	1147	1535	184.7	51.9	63.9
	1974-75	1110	1467	187.6	55.1	66.4
	1975-76	963	1606	178.5	53.6	53.6
	1976-77	1155	1641	163.4	51.9	73.4
	1977-78	860	1594	186.3	61.0	60.1
	1978-79	956	1578	178.3	55.1	69.4
	1979-80	1093	1613	169.8	54.1	67.6
	1980-81	1043	1611	175.9	56.3	66.5
	1981-82	1193	1606	166.2	55.4	76.6
	1982-83	1126	1611	166.6	52.7	82.8
	1983-84	1070	1496	169.2	52.6	79.5
	1984-85	982	1488	167.4	50.6	81.5
	b ± S.E.	6.52 ± 8.47	-1.07 ± 5.10	-1.63 ± 0.54	-0.14 ± 0.24	1.22 ± 0.50
IWP	1973-74	1166	1630	197.3	52.6	65.8
	1974-75	1221	1536	180.3	54.3	66.6
	1975-76	1037	1657	193.6	53.3	56.0
	1976-77	1237	1795	161.2	53.3	75.1
	1977-78	857	1585	185.5	61.1	64.9
	1978-79	1017	1682	170.4	55.2	66.3
	1979-80	1048	1701	172.2	54.2	65.0
	1980-81	1039	1620	175.1	56.3	67.7
	1981-82	1195	1641	168.9	57.7	72.4
	1982-83	1232	1692	167.2	53.8	78.8
	1983-84	1055	1544	155.1	52.3	74.7
	1984-85	1047	1563	169.9	50.6	84.1
	b ± S.E.	-3.70 ± 9.99	-3.72 ± 6.47	-1.83 ± 0.23	-0.17 ± 0.23	1.49 ± 0.46
CONTROL	1979-80	1155	1618	163.4	54.4	66.9
	1980-81	1035	1606	176.1	57.5	65.8
	1981-82	1176	1628	169.0	58.1	68.7
	1982-83	1204	1684	171.4	55.4	68.4
	1983-84	1078	1573	172.8	54.8	67.2
	1984-85	1080	1631	173.4	52.9	77.9
	b ± S.E.	-6.12 ± 26.70	0.62 ± 14.80	1.21 ± 1.54	-0.52 ± 0.69	1.68 ± 1.26

** Significant at 5% level

Genetic parameters like heritability and genetic correlation for the traits have been estimated and presented in Tables 110-111.

Table 110. Heritability estimates of production traits

	IWK	IWM	IWN	IWP	Pooled
BW 20					
S	0.63 ± 0.10	0.41 ± 0.07	0.33 ± 0.07	0.52 ± 0.09	0.48 ± 0.04
D	0.18 ± 0.06	0.22 ±0.06	0.29 ±0.07	0.12 ± 0.06	0.21 ± 0.03
S+D	0.40 ± 0.05	0.32 ± 0.04	0.31 ± 0.04	0.32 ± 0.04	0.34 ±0.02
BW 40					
S	0.68 ±0 .11	0.17 ± 0.07	0.44 ± 0.09	0.53 ± 0.09	0.44 ± 0.04
D	0.12 ±0.06	0.78 ±0.10	0.27 ± 0.07	0.08 ±0.06	0.35 ± 0.04
S+D	0.40 ± 0.06	0.48 ± 0.05	0.36 ± 0.05	0.31 ±0.05	0.39 ± 0.03

	IWK	IWM	IWN	IWP	Pooled
ASM					
S	0.17 ± 0.05	0.28 ± 0.06	0.26 ± 0.06	0.09 ± 0.03	0.19 ± 0.02
D	0.11 ± 0.06	0.11 ± 0.06	0.07 ± 0.06	-0.05 ± 0.26	0.06 ± 0.03
S+D	0.15 ± 0.03	0.19 ± 0.04	0.16 ± 0.04	0.11 ± 0.03	0.12 ± 0.02
EW 40					
S	0.35 ± 0.09	0.30 ± 0.09	0.51 ± 0.12	0.32 ± 0.10	0. 36 ± 0.05
D	0.14 ± 0.11	0.51 ± 0.12	0.27 ±0.11	0.15 ± 0.11	0.30 ± 0.06
S+D	0.24 ± 0.06	0.40 ± 0.06	0.39 ± 0.07	0.24 ± 06	0.33 ± 0.03
EP 40					
S	0.30 ± 06	0.21 ± 0.05	0.22 ± 0.06	0.22 ± 0.06	0.24 ± 0.03
D	0.08 ± 06	0.03 ± 0.06	0.11 ±0 .07	0.01 ± 0.06	0.06 ± 03
S+D	0.19 ± 04	0.12 ± 0.04	0.16 ±0 .04	0.12 ± 0.04	0.15 ± 02

Table 111. Genetic and phenotypic correlation of egg production with various traits (1984 – 85)

Strains	Component of variance – Covariance	EP 40 x BW 20	EP 40 x BW 40	EP 40 x ASM	EP 40 x EW 40	ASM x BW 20
IWK	r_{GS}	-0.054 ± 0.1351	-0.049 ± 0.1330	-0.757 ± 0.0731	-0.181 ± 0.1705	0.082 ± .01490
	r_{GD}	0.110 ± 0.3543	0.684 ± 0.2374	-0.592 ± 0.3028	-0.449 ± 4729	0.237 ± 0.2732
	r_{GS+D}	0.257 ± 0.1245	0.095 ± 0.1275	-0.649 ± 0.0927	-0.248 ± 0.1622	0.129 ± 0.1263
	r_P	0.088 ± 0.0196	0.004 ± 0.0202	-0.466 ± 0.0176	-0.140 ± 0.0289	-0.174 ± 0.0183
IWM	r_{GS}	0.217 ± 0.1436	-0.302 ± 0.2001	-0.860 ± 0.0418	-0.256 ± 0.1829	0.064 ± 0.1404
	r_{GD}	0.064 ± 0.5396	0.615 ± 0.2314	-0.190 ± 0.7315	-0.404 ± 0.4166	-0.079 ± 0.2763
	r_{GS+D}	0.176 ± 0.1407	0.034 ± 0.1257	-0.762 ± 0.0708	-0.090 ± 0.1516	.0021 ± 0.1182
	r_P	0.169 ± 0.0193	0.016 ± 0.0204	-0.406 ± 0.1794	-0.142 ± 0.0257	-0.236 ± 0.0181
IWN	r_{GS}	0.331 ± 0.1537	-0.404 ± 0.1392	-0.816 ± 0.0582	-0.330 ± 0.1594	-0.272 ± 0.1470
	r_{GD}	0.240 ± 0.2625	0.345 ± 0.2699	-	-0.316 ± 0.3306	-0.839 ±0.0919
	r_{GS+D}	0.295 ± 0.1212	-0.171 ± 0.1321	-0.758 ± 0.0707	-0.325 ± 0.1198	-0.445 ± 0.1021
	r_P	0.213 ± 0.0205	0.023 ± 0.0216	-0.422 ± 0.0188	-0.194 ± 0.0274	-0.284 ± 0.0188
IWP	r_{GS}	-0.014 ± 0.1492	-0.145 ± 0.1465	-0.555 ± 0.1515	-0.009 ± 0.1971	-0.434 ± 0.1491
	r_{GD}	-0.109	-0.306	0.874 ± 0.3766	-0.343	0.512 ± 0.3880
	r_{GS+D}	-0.024 ± 0.1627	-0.0168 ± 0.1632	-0.831 ± 0.1594	-0.082 ± 0.2099	-0.355 ± 0.3171
	r_P	0.121 ± 0.0257	-0.029 ± 0.0210	-0.339 ± 0.0195	-0.064 ± 0.0298	-0.199 ± 0.0194

Dwarf layer

Jain (1980) reported the means for day old age for dwarf (dw^-) pullets, normal (dw^+) pullet, dwarf (dwdw) male and heterozygous (dw dw^+) males were 31.32, 31.83, 32.25 and 31.6 gm respectively. The dwarf pullets weighed 1.59% less at day old and 26.8% less at 8 weeks age than normal. The interaction effect between sire x dam genotype was found non-significant. It was found that breed difference for egg weights, egg production, age at sexual maturity and 20 weeks body weight was highly significant. Phenotypic correlation showed negative correlation of age at sexual maturity with egg production and 20 weeks body weight.

Baghel (1981) and Khan and Baghel (1983) while estimating the egg production and egg weight of dwarf pullets under variable dietary protein and energy levels reported significant effect of crude protein and ME on 21 to 40 weeks egg production of dwarf layer, which improved from 61.64 to 72.53 egg when protein level was increased from 14 to 18% but dropped from 72.78 to 57.83 eggs when dietary energy level were increased.

Egg weight was also significantly affected. Khan and Baghel (1983b) showed that dietary crude protein has little effect on food consumption of dwarf pullet but had significant influence on production of an egg and 1 kg egg mass. Higher energy would increase food consumption without improving feed utilization efficiency. Verma (1981) and Verma and Khan (1983a) studied the influence of sex-linked recessive dwarfing gene on layer genome and indicated first flock egg for Narmada-XL dwarf egg type pullets, but on individual basis for normal broiler pullet. Highly significant effect was observed for body weight at 20 weeks. Khan and Verma (1983b) reported 79.6, 66.2 and 64.7 eggs respectively for Narmada-XL dwarf egg layer, dwarf broiler and normal broiler pullets. Narmada-XL was significantly superior in egg production than other two genotypes. Dwarf pullets laid more membranous and soft shelled eggs. Tiwari (1982) and Khan et al. (1985) indicated better survivability in dwarf pullets. They further suggested that body weight and egg production are more closely associated in positive direction in pullets carrying sex linked dw gene with its dominant dw^+ allele. The mean plasma sodium concentration of 167.78 meq/lit, 161.55 meq/lit and 152.59 meg/lit were recorded for Narmada-XL, dwarf broiler and normal broiler pullets. Gitte (1980) observed less (40.74-58.04 mg/100 serum) serum cholesterol in egg type dwarf than white leghorn bird. Similarly, the eggs laid by dwarf bird contain less cholesterol. Pandey et.al. (1995) reported that crossbred dwarf pullet showed less decline in egg production (from 83.3% to 50.9%) against purebred (from 87.7 to 34.2%) with the rise of summer temperature from 25.5° to 43.1° probably due to little change in feed consumed. The production efficiency was superior in cross bred dwarf. Results indicated that crossbred dwarf were more efficient than purebred on overall performance basis under summer heat. Raut (1997) and Raut et al. (1998) compared the intense and crossbred dwarf mini layer under different dietary protein-energy levels in summer season and reported that cross bred hens performed significantly better than inter-se dwarf hens for most of economic and feed utilization traits. Protein was found to have significant effect for FE/egg in (1-6 weekly) and average food consumption. Genotype accounted for maximum percent of variability indicating more importance for economic and feed utilization traits. Agrawal (1997) and Agrawal et al. (1998) studied the association of deep body temperature with production performance and nutrient level effect on mini layers under summer stress and reported that increase in deep body temperature in crossbred and inter-se dwarf hens causes decline in egg production, egg weight, and change in egg quality. Protein and energy, energy x Genotype and protein x energy x Genotype combinations were important for economic traits.

Development of small bodied colours birds for tribal and rural areas.

The project envisages studies to explore the possibilities for the development of small bodied coloured bird for use in rural and tribal areas. The sex linked recessive dw gene to impact barring feather pattern extending towards solid black colour. The id gene which was with low frequency in the population was considered for bluing shanks, wattle and ear lobes. Segregating generation showed feather colour variations in ratio of 64.66, 23.0, 12.34 percent as black barred + solid black, brown and white respectively. The white produced significantly higher number of eggs with smallest egg size than other colour variants.

The juvenile body weight at 4 and 8 weeks of age improved from 188.5 g to 202.6 g, and 426.1 g to 452.4 g. from base to S_2 generations. Body weight at 20 and 40 weeks changed by +141.5 and 72.4 g over generations. The mean egg number showed little change to direct selection for 32 weeks (-0.6) egg number. Almost similar trend was observed up to 40 weeks (+1.3 egg) of age from S-0 to S-2 generations. Against the expected response of 3.16, the realized observed positive change was 2.7 g in egg weight at 40 weeks of age. The gain from 32 to 40 weeks of age was maximum (+4.6 g) in S-2 generation, but expected correlated response was 1.05 g.

Mortality in S-0 and S-1 generation was within narrow limits. Gambaro constituted 23.4% mortality in S-2 generation with increased associated mortality due to other causes at 23.2%. Heritability for juvenile body weight ranged from 0.12 to 0.31 over generations and was low but consistent showing dam component values higher than the sire except for S-0 generation. Similar trend was observed for egg production, body weight, egg weight and age at sexual maturity.

The crossbred dwarf showed superior egg production (mean 82.4 egg) than its contemporary purebreds (71.8 eggs) with average heterosis of 6.2 percent. The egg weight was 50.4 g for pure dwarf against 49.5 g. for crossbred. The body weight of cross bred dwarfs was 146 g lower than purebred (1258.7 g) at 40 weeks of age. The crossbred consumed less feed than purebred. Under summer heat, the crossbred maintained their normal feed consumption (71.6 g) but purebreds showed a decline of 14.7 g/ day. The experimental birds mean values are superior to any indigenous purebred flock. The birds look as a replica of desi hen with the exception of slightly smaller legs (Table 112).

Table 112. Characteristics of improved strains and desi chicken

Trait	Improved strains	Desi hen	Difference
BW 20, wks (g)	926	730	+196
BW 40, wks (g)	1112	1100	+158
EP 40, wks (g)	82.4	38.0	+44.4
ASM (days)	163.8	212.0	-48.2
EW 40, wks (g)	49.5	39.0	+11.6
Egg colour Scavenger system/annual	Tinted brown 110-120	Brown 60	 +50
Feather colour	Solid black/Barred	Variable Colour	

Development of Dwarf broiler breeder dam line

Indian Council of Agriculture Research in phase III and VIII plan in view of diversification of studies in international scenario intimated to initiate study on sex linked dw gene under broiler genome during 1990-91. The nucleus stock was available with J.N.K.V.V. Jabalpur. Since then, J.N.K.V.V. Jabalpur housed this genome as *inter se* breeding population. This actual technical programme with objectives was approved during the year 1993-94 by ICAR. Two sub lines from dwarf broiler breeder dams viz. (i) DBG (dwarf bodied growth line) (ii) DBE (dwarf bodied egg weight line) were generated from a common dwarfing gene carrying population. The DBG sub line was being propagated with males and females selected on body weight at 4 weeks age whereas, DBE sub line was propagated with males selected on body weight at 4 weeks and females selected initially on 4 weeks body weight and subsequently, their 32 weeks egg weight.

The breeding population structure of inter-se dwarf broiler breeder dam population in different generation S-1 – S-5 generated in first phase of VIII plan are presented in Table 113. The number of sires and dam varied from 24-43 and 144-258 dams over generations of two sub line population i.e. DBG and DBE respectively. The effective population size utilized was 82-130 in DBG whereas 82 and 127 in DBE population respectively in S-2 and S-5 generation. The inbreeding coefficient ranged between 0.003-0.006 in selecting these populations. Considerable selection differential was achieved in S-2 - S-5 generation. The observed response more or less similar in both sub line population (S-3 - S-5 generation). However, in S-2 generation, expected response is little bit higher than the observed response.

Table 113. Breeding population structure over generation and direct selection to 4 weeks body weight of purebred dwarf

Particulars	S-1	S-2		S-3		S-4		S-5	
	DBG	DBG	DBE	DBG	DBE	DBG	DBE	DBG	DBE
No. of sires	32	24	24	30	30	43	39	38	37
No. of dams	180	144	144	180	180	258	204	228	222
Effective population	108	82	82	103	103	147	131	130	127
Inbreeding coefficient	0.002	0.006	0.006	0.005	0.005	0.003	0.004	0.007	0.004
Selection differential (g)	40	44	84	82	24	33	26	64	79
Expected response	16	.8	14	13	10	13	11	26	32
Observed response	82	.7	6	7	6	19	14	23	20

Fertility and Hatchability

The available 97 dwarf pullets (nucleus stock) were mated in batches with 16 males and two subline population from dwarf broiler breeder dam *viz.*(i) DBG (Dwarf bodied growth line) (ii) DBE (Dwarf bodied egg weight line) were generated from a common dwarfing gene carrying population. Generation-wise hatching performance of pure line dwarf are shown in Table 114. The observed mean fertility values obtained were 86.3 and 82.2% for DBE and DBG lines respectively whereas hatchability were 63.7 and 73.1% in the base generations. The fertility in S-2 - S-5 generation varied from 84 to 91.7% in DBE lines. The hatchability of DBG and DBE lines improved in S-2 generation but shown decline in further generation. Frequent electricity failure was the main reason for low hatchability. This also resulted in more number of weak/crippled chicks during S-4 generation.

Table 114. Generation-wise hatching performance of DBE and DBG lines

Generations		Fertility %	Hatchability %
S-1	DBG	88.9	62.8
	DBE	-	-
S-2	DBG	84.3	78.2
	DBE	81.3	72.3
S-3	DBG	84.0	65.6
	DBE	80.3	62.4
S-4	DBG	87.9	66.6
	DBE	87.7	60.2
S-5	DBG	91.6	59.3
	DBE	91.7	57.1

Body weight

The generation wise juvenile body weight at 4 and 6 weeks of age of DBG and DBE sublines respectively are presented in Table 120. The mean observed were 289 g and 499 g for DBG and 257 g and 478 g for DBE purebred chicks in S-5 generation. Body weight at both the ages of measurements are improved consistently over generations (S-2 - S-5) by 18-35 g in 4 weeks and 32-48 g in 6 weeks age. The random bred control line brought from PDP was maintained from S-2 population and weighed 303 g at 4 weeks and 406 g at 6 weeks of age. Deviation of PDP control with DBG line (S-2) generation showed that PDP chicks although heavier at 4 weeks of age but purebred dwarf chicks became higher by 20 g at 6 weeks of age. It is to emphasize here that the centre maintained only inter-se dwarf dam population in base and S-1 generation and then, on the basis of selection criterion mentioned earlier, two sub lines (i) dwarf bodied growth and (ii) dwarf bodied egg weight lines were formed from a common dwarfing gene population. So, the comparison of the lines in further generation was made considering the S-2 generation as a base for DBG and DBE population.

The generation wise production performance of dwarf broiler breeder dam from S-1 to S-5 generations (DBG and DBE) are presented in Table 115. The adult body weight was measured at 20 and 40 weeks of age. 20 weeks body weight recorded was 1.48 kg in DBG and 1.42 kg in DBE subline population in S-2 generation. There was a decrease in S-3, S-4 and S-5 generation in both the lines. The 40 weeks body weight recorded was 1.63 kg in DBG and 1.57 kg in DBE dwarf dam line which showed improvement over generations (S-4). More or less similar 20 and 40 weeks body weight was observed for both the lines.

Age at sexual maturity

Generation wise age at sexual maturity of purebred dwarf broiler breeder dams of DBG and DBE lines on individual bird basis are presented in Table 120. Age of sexual maturity at S-2 generation declined by 8 and 9 days in DBG and DBE lines respectively over previous generation. It was delayed in S-4 and S-5 generation and further improved by one day and 5 days in S-5 generation in DBG and DBE lines. The mean sexual maturity among lines varied from 153-174 days in S-1 -S-5 generation of purebred dwarf broiler pullets.

Egg weight

The egg weights of dwarf females were recorded at 32 and 48 weeks of age. The overall mean egg weight for 32 weeks of age in S-2 generation was 45.7 g and 48.7 g respectively for DBG and DBE lines. The 40 weeks egg weight showed remarkable recovery. In S-3 generation, overall mean egg weight at 40 weeks of age was improved in both the lines than previous generation (S-2) and DBE hens recorded marginally higher egg weight than DBG hens. The 40 weeks egg weight of both the lines was improved by 1.3-1.5 g in S-3 -S-5 generation over S-2 generation. The egg weight varied from 58-60 g in both the sublines during 61-70 weeks period recorded in post natural moulted birds in S-2 generation.

Egg production

The egg production up to 280 days of S-2 generation recorded was 76 eggs for DBG and DBE sublines. The egg production declined in further generation which might be due to delay in obtaining age of sexual maturity of birds of both the lines. The DBE line showed higher production than DBG lines over generations. The egg production in post natural moult has been recorded in 144 broiler breeder dams for 61-74 weeks period. Both the lines DBG and DBE showed more or less similar egg weight and % egg production (54.59- 54.16%). The annual egg production 21-72 weeks of age recorded on the basis of 200 hens in both the lines in selected flock were 187 and 193 in DBG and DBE populations respectively.

The egg production presented in Table 115 below shows approximate egg production over one year production cycle. The data for egg production in both the lines were recorded up to 68 weeks of age and the production for 4 weeks (69-72 week) was assumed on the basis of previous 4 week recorded data.

Table 115. Egg production in one production cycle in DBG and DBE

Trait	DBG	DBE
Egg production up to 40 weeks	65.4	67
Egg production from 40-60 weeks	72.8	76
Egg production from 61-68 weeks	29.2	30.0
Egg production from 69-72 weeks	14.6	15
Egg production adjusted for summer stress	4.6	4.7
Total egg production (21-72 week)	186.6 (187)	192.7 (193)

Khan *et.al.* 1987 reported that in dwarf broiler hens under cyclic summer hot and dry heat stress of 29.9 –45.4 °C, the egg production declined by 1.27% for a rise in 1°C maximum temperature. Considering the relation for S-4 selected stock the accumulative change in temperature was found to be 7.1 °C . The drop in egg production due to this change in cyclic temperature was 9% which accounted for about 4.6-4.7 eggs/ hen and were adjusted accordingly.

Heritability

The heritability, genetic and phenotypic correlation for juvenile and adult body eight and production traits of DBG and DBE lines (S-4 generation) was carried out considering 25 selected sires from each line (Table 154). The heritability estimates of 2, 4 and 6 weeks body weight of the selected pullets of DBG obtained were 0.26±0 .14, 0.83±0.15 and 0.30±0.16 respectively from sire component basis which indicate higher magnitude of heritability with low standard error and were precise. The estimate from dam component of variance were higher for second and sixth week average body weight than the sire component of variance for sire + dam component for juvenile body weight of DBG line chicks (Table 116).

The heritability estimates of DBE line obtained were 0.68±0.27, 0.68±0.31 and 0.90±0.31respectively of 2, 4 and 6 weeks body weight for sire + dam component of variance indicating higher heritability for these body weights. The heritability estimates of 20 weeks body weights from sire, dam and sire + dam component of variance were 0.91±0.52, 0.36±0.11 and 0.64±0.04 respectively, whereas corresponding heritability estimate for 40 week body weights were 0.26±0.18, 0.38±0.16 and 0.32±0.04 for DBG line. Maximum heritability from sire component of variance at 20 weeks of age in DBG line revealed the presence of sufficient variance at this age and at higher age i.e. 40 weeks of DBG lines of chicks. The heritability estimates in DBE line revealed higher values for 20 weeks but lower values for 40 weeks body weight from dam component of variance in comparison to sire component of variance. The heritability estimates for age at sexual maturity obtained were 0.41±0.18, 0.81±0.44 in DBG line and 0.60±0.23, 0.22±0.10 in DBE lines respectively from sire and dam component of variance indicating more importance of additive genetic variance for DBE line and maternal influence in DBG line for this trait (Table 117). Higher heritability estimate was obtained for 32 and 40 weeks egg weight of DBG line whereas moderate to high in DBE line. The results revealed that there exists considerable additive genetic variance which could be utilized for improvement through selection.

Heritability estimates recorded for 40 weeks egg production from sire, dam and sire + dam component of variance were low to moderate. DBG line showed higher values from sire component of variance indicating presence of genetic variance where DBE line showed higher value from sire component of variance. Analysis of variance showed highly significant effect due to sire and dam effect due to this trait.

Table 116. Heritability estimate of juvenile body weight of dwarf broiler breeder dam of S-4 generation

Components	Body weight					
	2 wks		4 wks		6 wks	
	DBG	DBE	DBG	DBE	DBG	DBE
Sire	0.26±0.141	0.54±0.326	0.83±0.250	-0.03±0.250	0.30±0.160	0.09±0.518
Dam	0.48±0.132	0.82±0.348	0.28±0.168	1.39±0.456	0.79±0.163	0.71±0.273
Sire + Dam	0.37±0.140	0.68±0.274	0.56±0.143	0.68±0.317	0.54±0.167	0.90±0.312

Note: DBG is the growth line and DBE is the growth and weight line of the dwarf broiler breeder dams.

Table 117. Heritability estimates for adult body weight and production traits of DBG and DBE

Economic traits	h^2 s		h^2 D		h^2 (S+D)	
	DBG	DBE	DBG	DBE	DBG	DBE
BW, 20 wks	0.91±0.36	0.46±0.15	0.36±0.11	0.61±0.25	0.64±0.27	0.54±0.32
BW, 40 wks	0.26±0.18	0.30±0.11	0.38±0.16	0.18±0.19	0.32±0.04	0.21±0.09
ASM	0.41±0.18	0.60±0.23	0.81±0.44	0.22±0.10	0.86±0.27	0.36±0.15
EP, 40 wks	0.36±0.26	0.14±0.03	0.31±0.03	0.25±0.12	0.44±0.17	0.18±0.18
EW, 32 wks	0.30±0.24	0.35±0.08	0.85±0.53	0.27±0.05	0.77±0.36	0.26±0.08
EW, 40 wks	0.63±0.10	0.35±0.05	0.53±0.11	0.33±0.16	0.43±0.06	0.34±0.18

Genetic correlation

Genetic and phenotypic correlation between juvenile body weight and adult body weight were estimated for selected dams of DBE lines for S-4 generation (Table 118). In S-4 generation, 2 weeks body weight was highly genetically related with 4 and 6 weeks body weight, whereas 4 week body weight was found moderately related with 6 week body weight of DBG line chicks. Phenotypically, early body weights (2 and 4 week) were found to be related to a moderate extent (rp 0.46 and rp 0.44) with 6 weeks body weight of DBE line chicks. The early body weight was found highly genetically related with adult body weights in DBG line whereas, moderately related in DBE line chicks.

The genetic correlation between adult body weight and age at sexual maturity was mostly negative (Table 119). Positively low to moderate value (0.05 ± 0.25 to 0.48 ± 0.17) of genetic correlation were obtained for DBG and DBE line between 20 weeks body weight and egg production up to 40 weeks as compared to that between 40 weeks body weight and egg production up to 40 weeks (Table 119 and 120). The phenotypic correlation of these traits obtained were low. The genetic correlation between age at sexual maturity and egg production was negative and high in magnitude for DBG and DBE line. The value ranged from –0.23 ± 0.15 to –.53 ± 0.12 for sire, dam and sire + dam component of variance. But age at sexual maturity with egg weight (32 and 40 week) resulted in positive genetic relationship for DBG line and negative for DBE line, suggesting that the association between these two traits was more due to genetic causes like pleiotropy and linkage than non-genetic factors including maternal effects.

Table 118. Genetic and phenotypic correlation coefficients among juvenile body weight

Components	BW 2 x BW 4		BW 2 x BW 6		BW 4 x BW 6	
	DBG line	DBE line	DBG line	DBE line	DBG line	DBE line
r_G Sire	0.97±0.030	0.00±0.00	0.79±0.246	0.70±0.171	0.55±0.307	0.00
r_G Dam	0.97±0.038	0.92±0.041	0.24±0.374	-0.17±0.071	0.52±0.341	0.08±0.250
r_G Sire + Dam	0.89±0.034	0.74±0.180	0.41±0.300	0.28±0.16	0.47±0.322	0.38±0.13
r_P	0.93	0.77	0.46	0.22	0.44	0.29

Table 119. Genetic and phenotypic correlation between adult body weight and production traits of DBG line

Correlation traits	Genetic correlation (rg)			Phenotype correlation (rp)
	rg(s)	rg(D)	rg(S+D)	
BW 20 x ASM	-0.66±0.22	-0.09±0.16	-0.26±0.18	-0.24
BW 20 x EP 40	0.13±0.03	0.16±0.17	0.09±0.09	0.08
BW 20 x EW 40	0.42±0.18	-0.02±0.19	0.12±0.19	0.52
BW 40 x ASM	0.31±0.16	-0.05±0.17	0.02±0.16	0.02
BW 40 x EP 40	-0.45±0.12	-0.17±0.17	-0.21±0.15	-0.14
BW 40 x EW 40	0.38±0.16	0.11±0.18	0.13±0.16	0.04
ASM x EP 40	-0.50±0.24	-0.38±0.15	-0.42±0.26	-0.41
ASM x EW 40	0.74±0.20	-0.05±0.20	0.18±0.10	0.12
EP 40 x EW 40	0.48±0.30	0.05±0.20	0.21±0.13	0.08

Table 120. Genetic and phenotypic correlation between adult body weight and production traits of DBE line

Correlation traits	Genetic correlation (rg)			Phenotype correlation (rp)
	rg(s)	rg(D)	rg(S+D)	
BW 20 x ASM	-0.03±0.33	-0.62±0.13	-0.19±0.21	-0.19
BW 20 x EP 40	0.05±0.26	0.48±0.17	0.20±0.19	0.16
BW 20 x EW 40	0.32±0.09	-0.38±0.20	-0.05±0.18	-0.16
BW 40 x ASM	0.32±0.35	-0.35±0.14	-0.13±0.20	-0.11
BW 40 x EP 40	-0.13±0.17	-0.01±0.17	-0.07±0.16	-0.04
BW 40 x EW 40	-0.38±0.12	-0.23±0.17	-0.08±0.14	-0.05
ASM x EP 40	-0.23±0.35	-0.53±0.12	-0.39±0.12	-0.35
ASM x EW 40	0.34±0.07	-0.01±0.18	-0.12±0.11	-0.07
EP 40 x EW 40	-0.29±0.04	-0.27±0.17	-0.28±0.13	-0.13

Heritability and Correlation for reproductive traits

Analysis to estimate heritability and genetic correlation for reproductive traits (fertility and hatchability) of DBG and DBE line was carried out using 97 and 93 sires and 506 and 444 dams respectively in S-2, S-3 and S-4 generations. The number of sires varied from 24-43 whereas dams varies from 116-230 between the lines in three generations. The generation-wise heritability estimates are summarized in Table 121 whereas genetic and phenotypic correlation pooled over generations of DBG and DBE lines for these reproductive traits are presented in Table 122.

The percent fertility of selected dams was heritable at an extent of 0.09-0.29 in DBG line and 0.00 and 0.29 in DBE lines from S-2 to S-4 generation from dam component of variance. The percent hatchability on total egg set basis (TES) and fertile egg basis (FES) was heritable to an extent of 0.13±0.07 and 0.09±0.06 respectively from the sire component in DBG line of S-3 generation. The estimates of DBG line were better than DBE line from dam component basis in S-4 generation. Low to moderate heritability estimates of fertility and hatchability indicated that hatching performance traits are mostly affected with environmental variation. On genetic scales, these traits could be improved by adopting the family selection. Maternal component and dominant deviations effects were more prominent in DBE line than DBG line due to the sex-linked additive genetic variance. The fertility % was positively genetically correlated with both the hatchability estimates and was of higher magnitude in DBG line on sire component basis. Similar trend for genetic correlation was noticed for DBG line from dam component basis for these traits (Table 122).

Phenotypic correlation coefficient between HTES and HFES was positive and of higher magnitude (rp 0.65 and rp 0.76) for DBG and DBE lines respectively. Higher positive genetic and phenotypic correlation estimates between fertility and hatchability suggested that the dams having higher fertility will also have better hatchability.

Table 121. Heritability estimates for hatching performance of dwarf broiler breeder dam lines

Gen.	Compo.	Fertility %		Hatchability %			
				TES		FES	
		DBG	DBE	DBG	DBE	DBG	DBE
S-2	S	0.03±0.05	0.06±0.05	0.04±0.05	0.04±0.05	0.00±0.04	0.04±0.06
	D	0.09±0.11	-0.10±0.09	0.06±0.10	0.04±0.10	0.03±0.10	0.08±0.10
	S+D	0.06±0.06	0.03±0.05	0.05±0.06	0.04±0.06	0.02±0.06	0.06±0.06
S-3	S	0.05±0.05	-0.05±0.04	0.13±0.07	-0.08±0.06	0.09±0.06	-0.05±0.04
	D	0.10±0.10	0.22±0.12	0.01±0.09	0.34±0.14	0.08±0.10	0.19±0.13
	S+D	0.07±0.06	0.11±0.07	0.07±0.06	0.17±0.08	0.09±0.07	0.09±0.08
S-4	S	0.09±0.06	0.00±0.05	0.05±0.05	0.02±0.05	0.05±0.05	0.04±0.05
	D	0.29±0.10	0.29±0.10	0.28±0.10	0.19±0.09	0.11±0.09	0.23±0.10
	S+D	0.19±0.06	0.15±0.07	0.17±0.06	0.10±0.06	0.08±0.06	0.14±0.07

Table 122. Genetic and phenotypic correlations for hatching performance of dwarf broiler breeder dam lines (pooled over years)

Lines	Genetic correlations			Phenotypic correlations
	Sire	Dam	Sire + Dam	
Fertility vs. HTES				
DBG	0.78±0.11	-	0.96±0.06	0.51
DBE	1.00±0.11	0.59±0.22	0.55±0.12	0.49
Fertility vs. HFES				
DBG	0.37±0.27	-	0.69±1.07	-0.06
DBE	-0.73±0.45	0.12±0.32	-0.01±0.38	-0.03
Fertility vs. HFES				
DBG	0.87±0.72	-	0.86±0.45	0.77
DBE	-1.00±0.01	0.88±0.06	0.82±0.03	0.81

Note : HTES is hatchability percent on total egg set basis, HFES is the hatchability percent on fertility egg set basis

Cross testing with normal male to produce commercial broiler chicks/at home trials

In earlier studies, the pure line dwarf hens were mated with one sire line (Hypeco genotype). The crossbred normal bodied chicks at 4 and 6 weeks of age weighed 890 g and 1230 g respectively. Similar cross in next year at home trial showed 658 g body weight at 4 weeks and 1181 g at 6 weeks pooled over sexes in commercial feed containing 23% crude protein and 2900 kcal ME/ kg diet. During the year 1993-94, the suggested technical programme envisaged to cross test dwarf broiler dam with normal sire from known male lines. Accordingly, yearly cross testing was carried out and results of home trial are shown in Table 123. During the year 1993-94, G_1 and G_2 genotypic groups were produced by mating of two different normal parent sire lines, simultaneously with dwarf broiler breeder dam. The performance of these chicks were tested under 4 dietary regimes constituting 21% and 23% protein and 2800 and 3000 ME Kcal/ kg diet. G_1 and G_2 broiler chicks weighed 631 and 663 g at 4 week and 1200 and 1265 g at 6 weeks of age respectively. G_2 genotype had significantly heavier body weight as compared to G_1 when both were fed with the diet having 23% protein and 2800 ME Kcal/ kg diet. The total meat yield was observed as 74-75 % in males and 72-73% in females in both the genotypes with non-significant differences at 6 weeks of slaughter age.

Table 123. Test performance of commercial broiler chicks from dwarf dam

Body weight (g)	RST 1991-92	Home trial / Farmer's trial				
		1993-94	1994-95	1995-96	1996-97	1998-99
Day old	35	34	35.2	34.8	35.3	35
4 wks	-	631 663	684	62 (680-890 FT)	797	732(G_1) 772(G_2)
6 wks	1410	1200 1265	1335	137 (1280-1440 FT)	1124	1297(G_1) 1327(G_2)
7 wks	1715	-	-	-	-	-
Feed consumption up to 6 wks (kg)	3.55	3.06 2.97	3.22	3.14	2.03	2.79(G_1) 2.92(G_2)

Subsequently in the year 1994-95, commercial broiler chicks were obtained by simultaneously crossing from dwarf dams (G-1) and normal dams (G-2) with normal broiler sires. G-1 and G-2 attained body weight 624 g and 628 g at 4 weeks and 1213 g and 1335 g at 6 weeks of age respectively. The body weight of pure bred dwarf population at 4 and 6 weeks of age were 254 g and 426 g. During the year 1994-95, the commercial broiler chicks obtained from dwarf dams were supplied to different farmers and it was found that mean body weight at 6 weeks varied from 1280 –1380 g and mortality ranged from 2.8-5% during the six weeks period. In farmer trials, the corresponding information during 1995-96 ranged from 1280-1440 g at 6 weeks age. During the year 1996-97, the performance of commercial broiler chicks produced by mating of normal sire DBG and DBE lines dam were tested during summer under control and open house system. At 6 weeks of age, body weight recorded was 1124 g during summer for commercial broiler chicks produced from DBG dam which indicated that the heat tolerance capacity of dwarf dam commercial broiler chicks is more in summer.

The commercial broiler chicks produced from the crossing of dwarf broiler breeder dam with normal broiler sire lines were distributed in different batches to farmers (during the year 1992-97) in various parts of Madhya Pradesh under farm testing programme. The four weekly body weight from farmers field trials ranged from 659-840 g and 6 weeks body weight from 1220 –1460 g over the years.

Random sample test

A sample of 650 eggs from dwarf broiler dam which were crossed with normal bodied sire were sent for broiler random sample test at Bangalore 1991-92. The mating design of parent is presented below:

Parents	Sire	Dam
Genotype	Normal ($dw^{+}Dw^{+}$)	Dwarf (dw^{-})
Progeny genotype	Male ($dw^{+}dw^{+}$)	Female (dw^{+})

The results of the test were very encouraging indicating promise in the performance of commercial broiler chicks produced from dwarf broiler dam. The detailed test results are summarized in Table 124.

Table 124. Performance of commercial broiler chicks in Random sample tests at Bangalore 1991-92

Particulars	Dwarf broiler dam commercial chicks	Top entry commercial	Bottom entry
Entry no.	8	3	5
Day old body weight, (g)	35	39.03	37.33
BW 6, wks (g)	1410	1580	1220
BW 7, wks (g)	1715	1935	1.430
Feed consumption (kg)			
0-6 wks	3.55	3.820	3.310
0-7 wks	4.650	4.959	4.636
FCR			
0-6 wks	2.518	2.418	2.713
0-7 wks	2.711	2.563	3.01

The results are indicative of the fact that growth potentials of dwarf female broilers are comparable with the commercials. In 7th week body weight, the ranking of commercial chicks was the best 5th out of nine entries. Other parameters were comparable with commercial entries.

RST (1993-94)

In the year 1993-94, eggs were sent to random sample test Hesaraghatta, Bombay and Hyderabad. Bangalore test suffered heavy mortality from IBD, results of Bombay RST were also not up to the mark. Due to incubator failure, only few progenies could be obtained in Random sample test conducted at Project directorate, Hyderabad, (IV test). However, the performance was better than Ludhiana and Bangalore Centre for body weight at 6 and 7 weeks of age.

RST (1996-97)

In the year 1996-97, a sample of 650 eggs each randomly collected from cross of DBG and DBE dwarf broiler dam and with coloured normal broiler sires were sent to RST for broiler performance test at Gurgaon. The results were not up to the mark, which might be due to following reasons:

i. The mortality in the chicks was about 50% in both the entries during test period which indicated that chicks were carrying some slow infection resulting in high mortality and poor growth.

ii. DBG and DBE lines were crossed with coloured normal bodied broiler sire which was in an initial phase and maintained for developing dual purpose variety.

iii. The age of birds of DBG and DBE lines were around 30 weeks while sending the eggs for RST.

In the year 1997-98 under the IX plan period, considering the overall results of S-2-S-5 generation of DBG and DBE subline purebred dwarf population, it was deduced that both the lines performed and behaved more or less in similar manner with respect to growth production and reproduction trait. The commercial broiler chicks which were produced for crossing of purebred DBG and DBE commercial dams with normal bodied broiler sire also exhibited more or less similar growth, feed efficiency and mortality pattern. It is to emphasize here that the commercial chicks were produced by direct crossing from purebred dwarf dams and also the normal sire utilized for crossing is not the elite sire, thus resulting in lower body weight of broiler chicks. In most of the cases, normal bodied growth line (NBG) which was a synthetic population developed from meat controlled line obtained from PDP and maintained from the year 1994-95 were utilized for production of commercial broiler chicks. This line was discontinued in year 1998-99 as per the modified technical programme to obtain sire line from nearest AICRP centre.

Looking into similar performances of DBG and DBE lines, it was directed by PDP to maintain only single source large population as purebred dwarf population followed by testing which meant crossing it with a dwarf male with normal broiler dam line so as to produce crossbred dwarf for evaluating its performance for different dam line traits.

As per the modified technical programme in the year 1998-99, a single large purebred dwarf broiler breeder dam population was generated in 4 hatches by pooling two existing sublines (DBG and DBE) by utilizing 68 sires and 408 dams selected parents. The juvenile body weight and other economic traits for dam line were evaluated.

On overall four hatch basis, the percent fertility obtained was 92.13% whereas the percent hatchability was 75.35 % and 81.78 % respectively on total egg set and fertile egg set basis for pooled population. The values were significantly higher than obtained for previous sub population generations. The effective population size utilized for generating the pooled dwarf broiler dam was 233.1 with inbreeding coefficient of 0.002. The mean of juvenile body weight of single purebred dwarf broiler population on overall 4 hatch basis recorded were 282 g at 4 weeks and 508 g at 6 weeks of age. Within hatches, the body weight ranged from 278-284 g at 4 weeks whereas 497-513 g at 6 weeks of age. The adult body weight (20 weeks and 40 weeks) recorded during the year for pooled purebred dwarf population are 1362±6.8 and 1789±8.3g respectively on overall 4 hatch basis which is significantly higher than previous subpopulation. Egg weight at 32 weeks of age was 44.3 g and at 40 weeks of age, it was 52 g on overall four hatch basis. The 40 weeks egg weight is little bit higher than previous subpopulation generation. The average egg production up to 40 weeks of age for pooled population was 58.90 eggs which varied from 58.10 to 59.70 eggs within the hatches.

The overall mortality in pooled population was recorded as 3.3% and 6.3% respectively, during 0-8 days and 2-6 week of age. Coryza was found to be the major cause of mortality in chicks during these ages.

The summary of selection records over generation in purebred dwarf broiler breeder dam G-0 to G-5 are presented in Table 125. The number of sires and dams contributed to regenerate dwarf dam population in different generation varies from 49-68 and 222-408 respectively. G-1 generation was hatched utilizing 60 sires and 360 dams with effective population size 206 and inbreeding coefficient of 0.002.

Table 125. Summary of selection records over generations in purebred dwarf broiler dams

Particular	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04
No. of sires	68	60	54	49	50	37
No. of dams	408	360	324	294	300	222
Effective numbers/popu.	233	206	187	168	171	127
Rate of inbreeding/Inb. coe.	0.002	0.002	0.003	0.003	0.002	0.004
Av. effective sel.diff. (g)	63 (4)	71 (4)	74 (4)	92 (6)	116 (6)	118 (6)
Phenotypic std. dev.	61	64	55	103	92	98
Selection intensity	1.02	1.11	1.36	0.90	1.26	1.20
Expected response	25	28	30	37	46	47
Observed response	9	33	62	17	166	14

Selection differential was improved over generations while the intensity of selection observed ranged from 1.02-1.36 and observed response improved from 9 g - 62 g (G-0-G-5) with 4 week body weight and 92-166 g with 6 week body weight as selection criteria (G-3-G-5 and App-3).

The overall percent fertility and hatchability and juvenile body weight over generation to generation are presented in Table 126.

Table 126. Hatch-wise means of fertility and hatchability and juvenile body weight

Year	Hatch	Fertility %	Hatchability %	Body weight (g)	
				4 weeks	6 weeks
G-0	I	90.4	84.7	279	513
	II	92.5	78.5	278	507
	III	94.1	81.6	286	513
	IV	91.8	82.3	284	497
	Average	92.1	81.8	282 (4607)	508 (4407)
G-1	I	89.9	47.8	318	555
	II	84.1	54.6	306	539
	III	86.2	60.4	313	544
	IV	88.0	55.9	322	554
	Average	86.9	55.5	315 (2868)	548 (2584)
G-2	I	87.1	37.8	342	568
	II	88.8	40.7	315	566
	III	89.8	46.1	327	554
	IV	89.1	48.1	322	565
	Average	88.5	43.0	327 (2503)	563 (2399)
G-3	I	91.5	94.3	343	574
	II	90.8	90.2	364	578
	III	88.6	83.9	349	587
	IV	90.7	83.9	355	580
	Average	90.1	88.0	353 (2711)	580 (2667)

Year	Hatch	Fertility %	Hatchability %	Body weight (g)	
				4 weeks	6 weeks
G-4	I	80.5	50.8	483	761
	II	81.2	69.6	456	724
	III	71.7	55.4	498	748
	IV	78.2	52.4	475	750
	Average	77.4	56.1	478 (2632)	746 (2579)
G-5	I	86.9	70.9	480	758
	II	88.9	87.2	481	772
	III	92.3	86.7	498	765
	IV	86.6	86.0	481	734
	V	82.9	78.7	478	770
	Average	88.0	82.9	484 (3308)	760 (3230)

At 18 weeks of age, 200 males and all survived females were housed in cages for evaluation of egg production and other economic traits. Generation wise (G-0-G-5) production performance of purebred dwarf broiler breeder dams are presented in Table 127. The 20 weeks body weight ranged from 1.36-1.66 kg and 40 weeks body weight from 1.74-2.01 kg between G-0-G-5 generations. Both the adult body weights consistently improved over the generations. Less variation within hatches for these body weights indicated uniformity in these populations.

Age at sexual maturity recorded was 170 days in G-0 generation and it improved by 9 days and was recorded as 161 days in G-5 generation. The egg weight recorded at 32 and 40 weeks of age was 44.3-45.8g and 52.1-55.9 g respectively. 28 weeks egg weight recorded were 43.3, 45.2 and 45.7 g respectively for G-3-G-5 generation. Very little improvement was observed in the egg weight measured in these ages over previous generation. The egg production up to 280 days of age was recorded as 61 and 64.6 eggs in G-3 and G-5 generations respectively. For further recording of egg production up to 72 weeks of age, a total of 200 hens of pooled purebred dwarf population from selected flock in each generation was maintained to arrive at egg production over one year production cycle. The corresponding estimates ranged from 184-197 eggs from G-0-G-5 generation. Annual egg production consistently improved over generation to generation. It is to emphasize here that the dwarf broiler dam laid their maximum number of eggs approximately 45% between 41-60 weeks of age. On an average % production recorded were 30% between 20-40 weeks age and 25% from 61-72 weeks age (12 weeks period) in its one year production cycle.

Table 127. Generation-wise performance of purebred dwarf broiler breeder dam

Traits	Generation					
	G-0	G-1	G-2	G-3	G-4	G-5
No. of birds housed	1468	785	728	752	762	1135
BW 20, wks (kg)	1.36	1.40	1.38	1.41	1.57	1.66
BW 40, wks (kg)	1.79	1.74	1.75	1.79	1.92	2.01
ASM (days)	170	167	166	165	162	161
EW 40, wks (g)	52.1	52.8	53.2	53.6	55.6	55.9
EP 40, wks (Nos)	58.9	59.7	59.2	61	63.2	64.6
EP 72, wks (Nos)	184	186	189	192	194	197

The egg quality was studied considering 3 eggs/dam of selected breeder at 40 weeks age. After removal of shell membrane, the true shell thickness measured was 0.32-0.33 mm with Haugh unit score of 83-86. Blood spots and meat spots were not observed for purebred dwarf dam.

The confirmation traits were recorded at 6 weeks of age and measurements were 46.7 ± 0.21, 4.13 ± 0.16 and 5.11 ± 0.14 cm for breast angle, shank length and keel length respectively in purebred dwarf broiler dam of G-3 generation.

Genetic parameters

The heritability and genetic correlation estimates for various economic traits have been outlined in Table 128.

Table 128. Heritability estimates of various traits dwarf broiler dam line

Traits	Sire	Dam	Sire + Dam
BW 6, wks	0.44 ± 0.19	0.59 ± 0.31	0.52 ± 0.18
BW 20 wks	0.32 ± 0.14	0.49 ± 0.23	0.41 ± 0.16
BW 40, wks	0.26 ± 0.18	0.47 ± 0.25	0.37 ± 0.19
ASM, days	0.31 ± 0.07	0.36 ± 0.07	0.34 ± 0.08
EP 40, wks	0.29 ± 0.13	0.41 ± 0.23	0.35 ± 0.17
EW 40, wks	0.54 ± 0.11	0.43 ± 0.09	0.49 ± 0.08

Response

The phenotypic response in dwarf dam line in important traits is presented in Table 129.

Table 129. Phenotypic response in primary and correlated traits

Traits	Purebred dwarf		
	2001-02	2002-03	2003-04
BW 4, wks (g)	26	125	10
BW 6, wks (g)	17	166	14
BW 20, wks (g)	31	160	96
BW 40, wks (g)	23	137	89
AMS (days)	1	2.9	1
EW 40, wks (g)	0.4	1.9	0.3
EP 40, wks (Nos.)	1.8	2.2	1.1
EP 72, wks (Nos.)	3	2	3

Cross bred dwarf dam

As per the centre-wise programme, J.N.K.V.V. centre working with dwarf had to utilize the three normal bodied dam line to generate crossbred dwarf dams. Accordingly, to fulfil the technical programme, fertile eggs of three different normal bodied broiler lines were obtained from Central Avian Research Institute (CARI) and from the Project directorate Poultry Hyderabad. Centre had received the 1600 and 500 fertile eggs of normal bodied broiler dam line from CARI and 1050 from PDP, Hyderabad during the year 1999-2000. The detailed incubation and hatching performance of these lines are presented in Table 130. The overall percent fertility obtained was 85.63 and 85.98% respectively for coloured and white line of CARI, whereas 80.45% for PDP dam line. The hatchability percent on total egg set basis was lower for the line obtained from PDP dam line. The low percent hatchability is mainly due to invariable current load shedding, frequent electricity failure and non-availability of generator in the hatchery. After the measurement of 6th week body weights, all the males of these broiler dam lines were sold away and only females were kept for subsequent mating with purebred dwarf males to produce crossbred dwarf dams.

The mean juvenile body weight of three normal bodied broiler dam line (CARI colour, CARI white and Hyderabad) measured at 4 and 6 weeks of age are presented in Table 131 and other performance traits in Table 132.

Table 130. Summary of incubation and hatching of normal bodied broiler dam

S.No.	Particulars	C.A.R.I.		PDP, Hyd.
		Colour	White	
1.	Number of hatches	1	1	1
2.	Number of egg set	487	1576	2023
3.	Number of infertile eggs and dead germs	70	221	200
4.	Number of dead in shells	124	278	326
5.	Total number of chicks hatched	293	1077	497
6.	Number of week/crippled	20	80	39
7.	Number of good chicks	273	997	458
8.	Fertility percent	85.63	85.98	80.45
9.	Hatchability percent on TES	60.16	68.34	48.58
10.	Hatchability percent on FES	70.26	79.28	60.39

Table 131. Juvenile body weight of normal bodied broiler dam line

Age	Broiler C.A.R.I. Izatnagar		Dam line PDP, Hyderabad
	Colour	White	
BW 4, wks (g)	643+10.26 (264)	619+7.48 (9.8)	607+9.77 (427)
BW 6, wks (g)	1092+18.32 (252)	1064+13.62 (893)	1030+16.10 (419)

Table 132. Performance of normal bodied broiler dam line

Particulars	C.A.R.I.		PDP, Hyderabad
	Colour	White	
BW 4, wks (g)	643	619	607
BW 6, wks (g)	1092	1030	1064
BW 24, wks (g)	290	2826	2715
BW 40, wks (g)	3850	3720	3280
ASM (days)	173	169	176
EP 40, wks (Nos)	49	54	48
EW 40, wks (Nos)	60.6	59.3	60.1

Colour dwarf population

From the year 2002-03, as per the technical programme, a coloured population carrying dwarf gene will also be maintained in the centre for evaluation of dam line traits. Accordingly a base population carrying dwarf gene was regenerated. During the year 2003-04, colour dwarf male were crossed with coloured carrying sex-linked dwarfing gene for evaluation of dam line traits by utilizing 52 sires and 312 dams. A total number of 5647 healthy chicks were hatched in 5 hatches. The % fertility obtained was 88.8% and % hatchability 72.6% (Table 133). The overall hatch basis juvenile body weight recorded were 519 g and 678 g at 4 and 6 weeks age. The confirmation trait values were recorded higher than purebred dwarf (white plumage). After crossing of dwarf male with colour normal bodied dam. The 20 weeks body weight of colour dwarf increase to 1390 g and 40 weeks body weight to 1740 g. Birds matured at 156 d of age and produces 61.5 eggs of 51.3 g average weight in 280 days of age.

As compared to the white dwarf line, the coloured line matured 5 days earlier, produced eggs that were higher by 1.6 g at 20 weeks and 4.6 g at 40 weeks. However hen housed egg production up to 40 week of age was 2 eggs more than their white counterparts. Better egg quality was observed considering 3 consecutive eggs/dam.

Table 133. Performance of coloured dwarf broiler dam line

S.No.	Traits	Mean
1.	Fertility (%)	88.8
2.	Hatchability (%)	72.6
3.	BW 20, wks (g)	1390
	BW 40, wks (g)	1740
4.	Age at sexual maturity (days)	156
5.	EP 40, wks (Nos)	65.1
6.	EW 40, wks (g)	51.3

Performance of commercial broiler produced from dwarf dam

Purebred dwarf broiler sire was crossed with 3 lines of normal bodied broiler dam to produce three different crossbred dwarf population *viz.* CBD (Cc), CBD (Cw) and CBD (Hy). The commercial broiler chicks were produced by crossing of these crossbred dwarf dams with normal bodied broiler sire for evaluating the growth performance. The 6 weeks body weight obtained for normal sire x CBD (Cc) dam chicks was higher (1335 g) with higher feed efficiency (1.9) followed by N x CBD (Cw) (Table 134).

Table 134. Average of juvenile body weight of commercial broiler produced by dwarf dams

Genotype	Sex	Body weights (g)				
		2 weeks	4 weeks	6 weeks	Av.	FCR
Normal broiler x dw CC	M	379 ± 8.76	841 ± 18.56	1489 ± 27.72	1335	1.90
	F	373 ± 4.52	668 ± 11.59	1181 ± 17.99		
Normal broiler x dw CW	M	372 ± 7.71	835 ± 22.19	1345 ± 33.90	1270	1.88
	F	359 ± 10.93	670 ± 26.08	1194 ± 43.44		
Normal broiler x dw Hy	M	366 ±13.15	814 ± 44.81	1357 ± 38.99	1265	2.12
	F	339 ± 7.12	645 ± 18.66	1173 ± 22.91		

Rural poultry production

During the XI plan period, Jabalpur centre was assigned the programme activity to work on development of new varieties suitable for rural poultry by utilizing local native germplasm viz., Kadaknath, Jabalpur colour population, CSML as well as colour dwarf population. The performance of different traits in these populations has been detailed in Tables 135-138.

Table 135. Body weight, conformation and performance traits of Jabalpur Colour and Kadaknath 2018–19

Particular	Jabalpur Colour (G-9)		Kadaknath (G-9)	
	Nos	Mean ± SE	Nos	Mean ± SE
BW 6, wks (g)	2805	803.7±5.8	1751	342.3±6.9
BW 20, wks (g), Female	918	1742.3±18.1	612	1090.4±19.3
BW 40, wks (g), Female	886	2016±22.3	591	1506.7±16.8
AFE (days)		124		141
ASM (days)		153		164
SL 6, wks (cm), Male		7.92±0.05		7.21±0.04
SL 6, wks (cm), Female		7.46±0.03		6.38±0.07
KL 6, wks (cm), Male		8.38±0.03		8.27±0.02
KL 6, wks (cm), Female		8.29±0.08		7.19±0.03
BA 6, wks (˚), Male		60.8±0.8		55.3±0.5
BA 6, wks (˚), Female		59.3±1.1		52.7±0.4
EW 28, wks (g)		49.5±0.16		40.4±0.03
EW 40, wks (g)		58.3±0.12		47.3±0.01
EP 40, wks (Nos)				
Hen Housed		91.9		57.3
Hen day		95.7±1.41		60.5±1.53
Survivor		93.1		58.8
EP 52, wks (Nos)	532		324	
Hen Housed		154.6		85.7
Hen day		159.3±1.9		89.1±1.6
Survivor		156.2		87.2

Table 136. Growth and production performance of CSFL Line.

Particular	CSFL	M_1	M_2
BW 5, wks (g)	1082±5.4 (p)	763±7.6 (p)	708.3±8.3 (p)
BW 20, wks (g)	2214.7±18.9	2067.3±19.4	2013.8±17.6
BW 40, wks (g)	2461.7±22.5	2281.3±26.4	2218.6±16.9
ASM (d)	181	176	169
EP 40, wks (Nos)	59±1.7	54±1.4	63±0.8
EW 40, wks (g)	60.8±0.82	60.1±0.76	55.2±1.1

Table 137. Generation wise performance of Jabalpur colour population

Traits	Jabalpur colour								
	G-1	G-2	G-3	G-4	G-5	G-6	G-7	G-8	G-9
BW 6, wks (g)	890	941	953	935	646	772	865	827	803
BW 20, wks (g)	1873	1865	1887	1954	1811	1863	1808	1785	1742
BW 40, wks (g)	2130	2144	2110	2283	2080	2116	2095	2067	2016
AFE (d)	129	127	124	130	129	126	129	121	124
ASM (d)	154	151	148	152	155	151	152	150	153
EW 28, wks (g)	50.4	50.1	50.3	49.6	50.0	50.3	50.1	49.8	49.5
EW 40, wks (g)	61.5	60.3	59.8	59.1	58.9	59.6	59.2	58.7	58.3
EP 40, wks (Nos)	81.8	84.1	87.3	86.1	87.5	89.7	91.3	93.6	95.7
EP 52, wks (Nos)	142	145.8	152.2	151	154.7	157.5	154.2	156.5	159.3
EP 72, wks (Nos)	248	256	2.58	262	258	259	261	263	Under prog.
Fertility (%)	96.1	94.1	91.2	93.2	93.4	85.3	80.4	82.9	89.54
Hatchability (%)	84.1	86.5	73.8	89.1	80.0	80.4	77.4	76.3	74.87

Table 138. Generation wise performance of Kadaknath population

Traits	Kadaknath								
	G-1	G-2	G-3	G-4	G-5	G-6	G-7	G-8	G-9
BW 6, wks (g)	241	311	346	361	299	339	381	397	342
BW 20, wks (g)	977	1032	1068	1079	1143	1107	1129	1135	1090
BW 40, wks (g)	1421	1487	1432	1481	1492	1520	1570	1530	1506
AFE (d)	149	150	143	157	146	143	147	142	141
ASM (d)	174	172	169	172	169	166	168	165	164
EW 28, wks (g)	40.8	41.2	40.9	41.3	41.2	40.7	40.3	40.7	40.4
EW 40, wks (g)	47.6	48.9	48.4	48.1	47.7	48.3	47.6	47.9	47.3
EP 40, wks (Nos)	40.9	45.3	47.1	55.4	51.3	53.8	55.7	58.2	60.5
EP 52, wks (Nos)	74	81.1	78.6	82.3	76.4	79.2	82.4	85.1	89.1
EP 72, wks (Nos)	123	125	129	137	132	129	134	137	Under prog.
Fertility (%)	96.2	79.4	91.2	89.6	96.6	84.3	86.2	87.1	88.21
Hatchability (%)	75.6	82.2	77.7	77.3	74.3	71.5	76.83	72.5	72.53

Performance of parent line

i. During XI plan Jabalpur centre was assigned the task initially for development of new varieties suitable for rural poultry production by utilizing dwarf, native colour and a local breed Kadaknath. Thus, a preliminary survey in the area was made about the choice of the farmer for the type of birds and most of the farmers (58%) indicated the interest for rearing of dual type birds followed by 24% for egg and 18% for rearing as meat purpose.

ii. Local native chicken Kadaknath birds with similar phenotypic appearance were procured and improved by selection. These birds weighed 1033 gm. at 20 wks. age, matured at 172 days of age and produced 123 eggs with an average 48 gm egg wt.

iii. Jabalpur colour (Normal coloured bird) were generated and improved by selection and attained 900 gm body weight at 6 wks of age, 1865 at 20 wks and 2140 at 40 wks of age. Birds matured at 151 days of age and produced 248 eggs with an average 61 gm egg wt.

iv. The multicolour mediocre broilers produced by crossing of colour normal sire x JBP col. female attained 1200 gm body wt. at 6 wks. age with 2.32 feed efficiency with 74% meat yield.

v. A multicoloured dual type birds was developed by crossing of JBP. col. male x Kadaknath female. The males of this F1 population (cross bred Kadaknath male) were back crossed with JBP col. female and commercial dual type chicken having (25% Kadaknath: 75% JBP col.) inheritance were produced. These birds were evaluated under farm and field condition.

Jabalpur colour male were crossed with Kadaknath female native fowl and cross bred chicks with 50% Kadaknath: Jabalpur colour 50% were produced. The males of this F1 population (cross bred kd. male) is back crossed with JBP col female and commercial dual type chicken having 25% Kadaknath: 75% JBP col. inheritance was produced and evaluated under farm and field condition for their growth and production performance up to 52 and 72 weeks of age.

Commercial cross chicks of Kadaknath 50: JBP 50% and Kadaknath 25: JBP 75% were also supplied to tribal farmers of Ajeevika group from Mandla district, Janni Programme JDSSA Mandla and to other farmers of adjoining areas of district Jabalpur which were reared mostly under free range with little supplement of kitchen waste during night hours. The body weight of 25% Kadaknath, Jabalpur 75% recorded under farm condition were 689, 911 and 1953 g respectively at 6, 8 and 20 weeks age on pooled sex basis. These dual type birds weighed 1730 g at 20 wks of age. Birds matured at 160 days of age and produced 71 and 138 eggs up to 40 and 52 weeks age respectively. Egg weight observed was 49.5 g at 40 weeks of age. The crossbred Kadaknath 50: JBP 50: chicks weighed 483, 634 and 1345 g at 6, 8 and 20 weeks age on pooled sex basis under intensive system of management. Birds matured at 165 days of age and produced 102 eggs up to 52 weeks age. The adult birds of Kadaknath 50% consumed 109 gm feed / bird / day whereas Kadaknath 25% consumed 114 gm / bird / day at institute farm.

Under field conditions, the birds (25% Kadaknath: 75% JBP col.) recorded on an average 410 g and 603 g b.wt. at 6 and 8 weeks age in free range conditions whereas 1580 g male and 1330 g female at 20 weeks age. The birds produced 49 eggs in free range upto 40 weeks age and 81 up to 52 weeks age. On the other hand, Kadaknath cross (50:50) bird attained 1010 g b.wt. at 20 week and 1520 g b.wt. at 40 weeks of age and produced 34 eggs upto 40 weeks of age and 69 eggs up to 52 weeks of age in free range conditions.

The performance of different cross combinations under intensive and extensive management systems has been presented in Tables 139-140.

Table 139. Performance of different crosses under intensive and extensive management system

Particulars	50% Kd x JBP 50%	JBP 50%: coloured dw 50%	Kd 25%: JBP col. 75%
Under intensive system			
BW 6, wks (g)	358	-	626
BW 8, wks (g)	-	-	840
BW 20, wks (g)	1325 (M)	-	2035 (M)
	1081 (F)	-	1691 (F)
ASM (days)	161	-	162
BW 40, wks (g)	1705 (f)	-	2568 (m) 1931 (f)
EP 40, wks (Nos.)	51	-	65.3 eggs
EP 52, wks (Nos.)	-	-	132 eggs
EP 72, wks (Nos.)	168	-	224
EW 40, wks (g)	49.3	-	50.2
Under extensive system Free range			
BW 6, wks (g)	274	355	330
BW 8, wks (g)	431	601	520
BW 20, wks (g)	1272(m) 1078(f)	1544(m) 1311(f)	1465(m) 1278(f)
BW 40, wks (g)	1732(m) 1396(f)	1938(m) 1610(f)	2263(m) 1680(f)
EW 40, wks (g)	40.5	43.1	48.8
EP 40, wks (Nos.)	-	-	43
EP 52, wks (Nos.)	-	-	75
EP 72, wks (Nos.)	121	134	173
Semi Intensive			
BW 6, wks (g)	430	540	515
BW 8, wks (g)	560	810	702
BW 20, wks (g)	1467(m) 1194(f)	1633(m) 1447(f)	1617m 1398(f)
BW 40, wks (g)	1841 (m) 1516(f)	2142(m) 1725(f)	2217 (M) 1785 (F)
EW 40, wks (g)	41.8	46.3	48.6
EP 40, wks (Nos.)	-	-	47
EP 52, wks (Nos.)	-	-	86
EP 72, wks (Nos.)	142	159	191

Table 140: Evaluation of crosses under intensive system and free range system by Ajeevika group and Janni programme

Particulars	50% Kd x JBP 50%	Kd 25% : JBP col. 75%
Under intensive system		
BW 6, wks (g)	483(P)	689(P)
BW 8, wks (g)	634(P)	911(P)
BW 20, wks (g)	1532(M)	2180(M)
	1160(F)	1730(F)
	1345(P)	1953(P)
ASM (days)	165	160
BW 40, wks (g)	2160 (M) 1720 (F)	2510 (M) 1870 (F)
EP 40, wks (Nos.)	58	71
EP 52, wks (Nos.)	102	138
EW 40, wks (Nos.)	48.7	49.5
EP 72, wks (Nos.)	Under progress	Under progress
Under Extensive system free range (Group-II) Ajeevika group & Janni Programme		
BW 6, wks (g)	315 (P)	410 (P)
BW 8, wks (g)	487 (P)	603 (P)
BW 20, wks (g)	1250 (M)	1580 (M)
	1010 (F)	1330 (F)
BW 40, wks (g)	1860 (M)	2240 (M)
	1520 (F)	1750 (F)
EW 40, wks (g)	41.7	48.3
EP 40, wks (Nos.)	34	49
EP 52, wks (Nos.)	69	81

Newly developed rural bird variety (Kd 25% : 75% JBP col.) was released in the name of Narmadanidhi for farmers for backyard poultry in a Release Function organized by Nanaji Deshmukh Veterinary Science University Jabalpur (M.P.). Performance of Narmadanidhi under different production systems has been detailed in Table 141.

Table 141. Performance of Narmadanidhi under intensive and extensive management systems

Particular	Farm	Field
BW 8, wks (g) (M) (F)	1106.6±14.3 789.2±12.7	752.4±16.7 648.2±21.4
BW 20, wks (g) (M) (F)	1840.2±23.5 1610.7±17.6	1635.5±12.9 1385±17.8
BW 40, wks (g) (M) (F)	2630±16.8 1840.3±22.7	2560.5±17.1 1680.1±21.7
ASM (days)	167	-
EP 40, wks (Nos.)	68±2.1	49±2.7
EP 52, wks (Nos.)	-	88.1±5.3
EP 72, wks (Nos.)	-	176±4.9
EW 40, wks (g)	49.1	47-48g
Shell colour	Dark brown	Light to brown

Significant achievements

Jawahar-260 (Commercial layer)

Breeders of egg type chicken are mainly concerned with the development of efficient layers in terms of feed efficiency, low chick cost, high egg production and less mortality. Consequent upon fourteen generations of selection and diallel crossing using 4 white leghorn strains, a commercial hybrid layer 'Jawahar-260' was developed. The White leghorn strain 'M' as male line and strain 'N' as female line was used to developed this hybrid layer.

Age of first egg – 138 days, Peak production – 26-28 wks., Hen day egg prod. (72 wks) – 270, Hen housed egg prod. (72 wks) – 259, Average egg weight – 1770 g., Layer house mortality – 0.5/month, Feed consumption – 1108 g/day. High tolerance power, Low layer house mortality, efficient feed conversion and high positive return over feed cost.

Narmada-XL (Dwarf commercial layer)

A mini white egg layer was developed by utilizing sex-linked recessive dwarfing gene. This bird was developed by crossing superior dwarf male line and a White leghorn female line. The bird weighed only 1.3 to 1.4 kg adult body weight and consumed only 80-85 gm feed per day. It produced 9-10 eggs of 50-52 gm size in place of five White leghorn birds. The bird has got superior tolerance power against heat and many infectious diseases.

Krishna-J (A replica of desi hen, for rural and tribal areas)

For the promotion of rural and tribal poultry keeping, a replica of indigenous hen (Krishna-J) with better economic viability has been evolved. It is a synthetic bird formed by utilizing sex-linked recessive dwarfing gene *dw*. This bird is a replica in terms of physical characteristics of indigenous hen with potentiality to produce 100% more eggs with higher egg weight under rural system and four times more production under intensive system of management. Birds have superior thermotolerance and resilience against many infectious diseases.

Body weight at 20 weeks – 926 (g), Body weight at 72 weeks – 1330 (g), Egg production up to 280 days (intensive system) – 83, Egg production up to 500 days – 240, Under Scavenger system – 110-120, Age at sexual maturity – 153 days, Egg weight (40 wks) – 50.6 g, Egg colour – Tinted brown, Plumage colour – Barred black, brown.

Dual purpose coloured bird for rural poultry

The coloured bird is more in demand due to its resemblance with the indigenous breeds. A need based technology to produce dual purpose coloured bird for rural and tribal area keeping is evolved by an economic alternate breeding policy by mating with coloured normal bodied synthetic sire line with Krishna-J female line. The plumage pattern varies from dark brown to multicoloured barred, black grey having long shank and single, pea and rose comb. Males attain 1 kg body weight in just 6 weeks of age. Bird produces more than 110 eggs in scavenger system and attained 1 kg body weight at 6 weeks of age under intensive and at 8 weeks of age under Scavenger system.

Vindhyachal Broiler

The field of commercial broiler production has undergone many changes in last decades. This has been achieved both as a result of intensive research and practical application of new techniques and ideas with the ultimate objective of developing varieties with improved feed efficiency and rapid growth. The '*Vindhyachal Broiler*' was produced by adopting an alternate breeding strategy by mating the normal bodied sire with the crossed dwarf broiler dam line. This bird saves 33% cost in feed, medicines and in management, thus reducing the day old chick cost.

Weight at day old – 39 gm, Weight at 6 weeks – 1410 gm, Weight at 7 weeks – 1715 gm, Feed consumption (0-6 weeks) – 3.55 gm, Total meat yield (%) – 81.8%.

Dwarf Broiler breeder dam (Parent line White plumage)

A single source dwarf broiler breeder dam line is developed by selection from a common dwarfing gene carrying population. These males, when crossed with normal broiler female reduce 30-35% body weight and improved egg numbers by converting them into dwarf (crossbred) which will be mated with normal bodied broiler sire for production of commercial broiler chicks. Dam have very high percent fertility (92%) and hatchability (88%). Bird weighed 910 g at 6 wks, 1800 g at 20 wks and 2350 g at 40 wks age. It matures at the age of 150 days and produced more than 210 eggs yearly of 57 g egg wt with more than 185 settable number of eggs. Birds consumed only 120-122 g feed/day, 3.5 to 4 g feed for production of per gram egg and 2.5 kg feed for per dozen egg. In comparison to normal broiler dam, the dwarf broiler dam is about 1 kg less in body weight and consumed 25-30% less feed and produced 26% more number of eggs and 12-15 more chicks/dam/year. In other words this dam line may be really the feed efficient broiler dam line. Further, dwarf pullets survive better under hot tropical condition, low nutritive plane and have high tolerance capacity to protozoan and other infections. It can also resist early moulting.

Colour dwarf birds

These birds have very high fertility (95.4%) and hatchability (86.3%). Birds weighed 1550 gm at 20 weeks and 1840 g at 40 weeks of age. It matured at the age of 151 days of age and can produce 78 eggs upto 40 weeks, 133 eggs upto 52 weeks and 243 upto 72 weeks age. Egg weight measured was 56 gm.

Kadaknath

Kadaknath which is also known as Kalamasi (black meat) is mostly habituated in hilly and tribal areas of M.P. (Jhabua, Dhar). Earlier these birds were procured and maintained under the department and maintained as random bred population. During the year 2007-08, a flock of Kadaknath bird was procured by the project and the population was propagated, evaluated and improved by selection and maintained as purebred Kadaknath population. The plumage colour pattern varies from bluish black with gold spangled, silver tinge. The shank, toes, skin are of various degree of slate colour. The comb, tongue, wattles are black to purple in colour. This bird produces black meat and all the internal organs also have black colouration. The meat is delicious and is highly relished by the tribal. A purebred Kadaknath bird under intensive system of management matures at 169 days of age and produces 133 eggs annually with average egg weight of 48 g. The average weight of adult male is 1.7-1.8 kg and female is 1.35 to 1.43 kg. Adult birds consumed 106 gm feed/day and produced 1 kg egg mass in 3.48 kg feed and 1 dozen eggs in 1.90 kg feed under intensive system of management. The adaptability was better in Kadaknath having flight characteristics, lowest mortality during growing phase and negligible mortality during laying phase. Birds have better percent fertility (90%) and hatchability (77%). Purebred population of Kadaknath (G-9) is available and conserved in the centre.

Jabalpur colour population (Parent line)

A normal bodied colour population synthesized from randomly bred multicoloured population. Males of multicoloured population were crossed once with elite coloured synthetic females. Thereafter, populations were inter-se mated and subjected to selection for generations for growth and egg production traits. The population is developed and improved by selection continuously. Plumage pattern varies from dark brown, black, grey barred and multicoloured having long shank and single, pea, rose comb. Birds have ability to grow faster and produce good number of eggs of heavier size. The day old chick weighs 40 gm and attained body weight 890 gm at 6 week, 1870 gm at 20 weeks and 2140 g at 40 weeks of age. Birds (G-3) matured at 151 days of age and produced more than 250 eggs of an average egg weight of 60 gm annually with more than 200 settable eggs. The shank length of male is close to 8 cm and female is 7.3 cm (at 6 week) with straight upright posture. Birds have good fertility (94%) and hatchability (86%). Adult birds consumed only 121 g of feed per bird/day. At present, G-9 generation is available and conserved in this centre.

Medium type Multicoloured chicks (Mediocre broilers)

Multicoloured mediocre broilers were developed by crossing of coloured synthetic sires with Jabalpur colour dams. These chicks were tested under farm and field conditions. The plumage pattern varies from brown, black, grey, mixed and resembles physically as replica of desi fowl. Broilers attained 1.1 to 1.3 kg body weight at 6 weeks of age by consuming 1.8 to 2.0 kg feed under intensive system of management. Under free range and semi intensive conditions, these chicks weighed 550 and 750 g body weight at 8 weeks of age. These broilers are suitable for tribal/rural poultry keeping for intensive coloured broiler production.

Narmadanidhi

A multi coloured dual purpose bird is developed by crossing and back crossing of Jabalpur colour and Kadaknath birds. Jabalpur colour males were crossed with Kadaknath females to produce cross bred chicks with 50% Kadaknath and 50% Jabalpur colour inheritence. The males of this F1 population was back crossed with JBP colour female and commercial dual type chicken having 25% Kd: 75% JBP col. inheritance was produced and evaluated under farm and field condition for their growth and production performance up to 72 weeks of age. The plumage colour pattern varies from black, brown, barred, grey to mixed colour. The body weight recorded under farm condition was 626, 840, 1587 g respectively at 6, 8 and 16 weeks of age on pooled sex basis. The dual type bird weighed 1691 and 1931 g body weight at 20 and 40 weeks of age respectively. Birds matured at 162 day of age and produced 65.3 eggs up to 40 weeks, 132 eggs up to 52 weeks and 224 eggs up to 72 weeks of age under intensive system of management. The adult birds consumed 116 g/bird/day feed and produced 1 kg egg mass by consuming 3.37 kg feed and 1 dozen eggs were produced by consuming 2.03 kg feed at institute farm.

Under field conditions, dual type commercial birds recorded 330 and 520 g body weight at 6 and 8 weeks of age on pooled basis. The adult female weigh about 1278 and 1680 g body weight respectively at 20 and 40 weeks age in free range/scavenging, whereas 1398 and 1785 g in semi intensive system. These dual type (25% kg: 75% JBP) birds produced 75-90 eggs up to 52 weeks of age and 171-180 eggs annually in free range, whereas 86 eggs upto 52 weeks and 191 eggs annually in semi intensive system of management. Egg production in free range system is variable ranging from 165 – 185 eggs depending on the availability of feeding material in the field with different farmers. The general practice adopted by most of the tribes for rearing this bird is without provision of supplementary feeding. However, some farmers provide kitchen waste, grains or feed waste and whatsoever available waste material of feed and vegetable sources. These birds perform better and are adapted well under village conditions having very less mortality, less prone to predation due to its medium size, strong legs, long shanks with better flight characteristics. These birds are very popular among farmers and have a greater demand in rural backyards. Farmers prefer these birds both for meat and egg purpose. Presently, the centre is propogating the variety by supplying fertile eggs and chicks to the farmers.

10 ICAR Research Complex for NEH Region, Tripura Centre, Agartala

All India coordinated research project on poultry improvement (Rural Poultry Production) was initiated at ICAR Research Complex for NEH Region, Tripura Centre, Agartala centre in the year 2000-01 and the actual work was started during the year 2001-02. However, prior to this AICRP centre was operated 1977-1985 at Agartala on layer production which was subsequently discontinued from 1985. Initially, the objective of this centre was to test the performances of various stocks developed for rural poultry production in Tripura. Later the objectives were modified as, to test the rural varieties developed by various organizations i.e., ICAR and SAUs and to develop location specific germplasm for rural poultry production.

In this regard, different poultry germplasm like Vanaraja, Giriraja, Gramapriya, Krishna J, CARI Nirbheek, CARI Shyama, Srinidhi, local germplasm (Tripura black and Tripura brown), Dahlem Red and Coloured broiler were procured from different centres and their performance was evaluated at ICAR Tripura Centre, Lembucherra under farm as well as at farmers' fields. The production performance of different economic traits of native germplasm (Tripura black and Tripura brown) was also evaluated. After evaluation, it was found that the performance of Tripura black was comparatively better than Tripura brown. Therefore, Tripura black was selected for developing new crosses. Other improved germplasm like Dahlem Red and Coloured broiler were also established at farm and their performance were also evaluated under agro-climatic conditions of Tripura. The purpose for establishing these parent lines was crossing these lines to evolve new variety (ies) of poultry, which would be suitable for rural poultry production. Location specific variety BND Cross chicken (Dual type chicken) has been developed for Tripura by crossing of Coloured Broiler, Tripura Black and Dahlem Red.

Achievements

Evaluation of different poultry germplasm in agro-climatic conditions of Tripura for rural poultry production

Initially, the objective of this centre was to test the performances of various stocks developed for rural poultry production in Tripura. Thus, different poultry germplasm like Vanaraja, Giriraja, Gramapriya, Krishna J, CARI Nirbheek, CARI Shyama, Srinidhi, local germplasm (Tripura black and Tripura brown), Dahlem Red and Coloured broiler were procured from different centres (Table 142) and their performance were evaluated at ICAR Tripura Centre, Lembucherra as well as at farmers' fields.

Table 142. Sources from which germplasm was procured at Tripura centre

Name of Germplasm procured	Sources
Vanaraja, Gramapriya, Srinidhi, Dahlem Red,	DPR, Hyderabad
Giriraja	UAS, Banglore
Krishna J	JNKW, Jabalpur
CARI Nirbheek, CARI Shyama, Coloured broiler	Central Avian Research Institute, Izatnagar
Local germplasm (Tripura black and Tripura brown)	Local farmers of Tripura

The body weights at different ages, fertility and hatchability was higher in Giriraja followed by Vanaraja, Srinidhi, Gramapriya, Krishna J., CARI Nirbheek, CARI Shyama both at the farm as well as field (Tables 143 and 144). The higher body weight in Giriraja and Vanaraja than other stock was due to the genetic makeup of the birds as they harbour broiler inheritance. The feed consumption was higher in Giriraja followed by Vanaraja and lowest in CARI Shyama. The age at sexual maturity was lowest in Gramapriya than the other other birds. The egg production upto 40 weeks of age was higher in Gramapriya and Srinidhi at both the locations. The broodiness was not observed although flying capacity was good in CARI Nirbheek and CARI Shyama due to the lower body weight of the birds.

Table 143. Mean Performance of economic traits of different rural poultry germplasm at the institute farm

Traits	Vanaraja	Giriraja	Gramapriya	Krishna J.	CARI Nirbheek	CARI Shyma	Srinidhi
BW 8, wks (g) M	1223±10.15	1426±10.83	751.5± 10.13	797.4±12.04	531.8±12.5	545.5±17.97	707.1±19.66
F	1113±12.81	1353±7.57	625.0 ± 12.76	592.9±12.24	457.9±9.72	414.5±9.03	626.9±7.89
BW 20, wks (g) M	2582±51.44	2783±42.46	2108±39.67	2001±68.05	1802±19.99	1594±24.48	2292±36.00
F	2056± 33.15	2243±56.41	1613±43.97	1549±42.24	1415±17.56	1195± 21.18	1760±35.00
BW 40, wks (g) M	3721± 51.90	4275± 63.62	3214±53.83	2820± 80.62	2667± 2.40	2073±45.27	3452±40.00
F	2710±48.86	3259±77.45	2442±47.65	1604±58.15	2091±31.01	1777±35.38	2322±30.00
A.F.E (days)	151.0	162.0	127.0	142.0	187.0	193.0	156.0
EP 40, wks (Nos)	38.13	32.63	62.13	16.40	37.32	29.76	62.74
EW 40, wks (g)	61.53±0.18	64.83±0.28	59.25	53.78±0.09	53.78±0.09	53.32±0.38	57.21±0.56

Table 144. Mean Performance of economic traits of different rural poultry germplasm at farmer's field

Traits	Vanaraja	Giriraja	Gramapriya	Krishna J.	CARI Nirbheek	CARI Shyma	Srinidhi
BW 8, wks (g) M	1006±20.54	1221± 37.90	-	-	-	-	682.3±18.27
F	921.5±11.97	1053±32.79					509.3±12.20
BW 20, wks (g) M	1321±48.60	1594±96.58	1084±21.35	_	929.6±17.65	813.0±27.64	1002.2±21.47
F	1099± 25.50	1365±78.15	928.2±29.14		730.6±15.03	594.5± 19.19	804.6±13.19
BW 40, wks (g) M	3374± 46.23	3986± 62.17	3034±52.84	2687± 79.20	2462± 28.05	2031±34.83	_
F	2433±56.73	2896±42.63	2193±62.49	1604±58.15	2021±28.39	1701±21.61	
ASM (days)	181.23	190.62	193.62	187.10	198.0±1.70	201.2±1.87	178
EP 40, wks (Nos)	29.64	23.74	34.62	8.23	26.31	25.26	32.50

It was concluded that for egg purpose, Gramapriya could thrive well on moderate feed supplementation followed by CARI Nirbheek and for dual/meat purpose, Vanaraja and Giriraja performed well in free range conditions of N.E. Region. Over all, the farmers were happy with growth rate as well as egg production performance of Gramapriya. The farmers reported to earn good amount of money by selling male birds and eggs.

Evaluation of performance of different economic traits of poultry germplasm to be used for developing new cross

The second objective was to develop such type of new variety which would be suitable for rural poultry production in agro-climatic conditions of Tripura. In this regard, firstly, the production performance of different economic traits of native germplasm (Tripura black and Tripura brown) was evaluated. After evaluation, it was found that the performance of Tripura black was comparatively better than Tripura brown. Therefore, Tripura black was selected for developing new crosses. Other improved germplasms like Dahlem Red (Egg type) and Coloured broiler (Meat type) were also established at farm and their performance was also evaluated under agro-climatic conditions of Tripura. The purpose for establishing these parent lines was crossing these lines to evolve new variety (ies) of poultry which would be suitable for rural poultry production.

Evaluation of performance of different economic traits of native germplasm of Tripura

The mean performance of different economic traits of native germplasm of Tripura has been given in Table 145. The average body weights at different ages were significantly higher in Tripura black in farm condition than Tripura brown. The body weights of both native germplasm of Tripura were similar at the field conditions. But overall, the native germplasm of Tripura has lower body weights than the improved germplasm developed for the rural poultry production. The average age at first egg (AFE) was significantly lower in Tripura brown than Tripura black. The egg weight was lower in comparison to all the improved stock *viz.* Gramapriya, Vanaraja, Giriraja, CARI Nirbheek etc. tested at Agartala centre of the AICRP on Poultry Breeding. The annual egg production of the native germplasm of Tripura was quite low under the field condition (58.06 to 69.83 eggs) in comparison to farm conditions. The higher egg production at the farm than the field was due to better feeding and management as well as restriction measures followed to reduce broodiness at the farm. The egg production of Tripura black was comparatively more than Tripura brown. The variation in the performance of different economic traits of distinct germplasm may be due to differences in genetic makeup of different germplasm, agro-climatic conditions, nutrition and managemental practices. Tripura black germplasm was more hardy and resistance to most of poultry diseases in comparison to Tripura brown.

Table 145. Mean Performance of different native germplasm of poultry of Tripura at the institute farm and field

Traits	Tripura black		Tripura brown	
	Farm	Field	Farm	Field
Fertility %	84.43	---	78.31	---
Hatchability %				
TES	78.96	80.37	69.38	81.39
FES	93.35	---	88.61	---
BW 4, wks (g)	153.5± 1.79	111.3±9.19	148.7± 4.27	120.5± 6.63
BW 8, wks (g)	317.0± 4.86	340.0±73.30	289.3± 5.27	268.8± 14.41
BW 12, wks (g)	545.8± 7.12	580.3± 51.49	497.7± 8.27	610.1± 53.78
BW 16, wks (g)	822.0± 10.97	743.8± 51.46	785.0±14.54	796.5± 44.49
BW 20, wks (g)	1062± 13.55	822.7± 37.93	1028±18.52	910.3± 40.48
BW 40, wks (g)	1444± 25.00	1314± 32.00	1320± 25.00	1213± 16.00
ASM (days)	160.0	172.2±2.19	143.0	147.7± 2.43
EW 40, wks (g)	38.18 ± 0.50	39.13 ±0.65	43.44± 0.46	37.24±0.68
EP 72, wks (Nos)	124.14	68.81 ± 4.61	116.27	58.06 ±1.60

Tripura brown

Tripura black

Figure 18: Native Chicken of Tripura

Evaluation of performance of Dahlem Red and Coloured broiler

The performance of improved germplasm like Dahlem Red (Egg type) and Coloured broiler (Meat type) was evaluated under agro-climatic conditions of Tripura (Table 146). Overall, the production performance of both the germplasm was found to be good at the organized farm conditions.

Table 146. Mean Performance of Dahlem Red and Coloured broiler at the institute farm

Traits	Dahlem Red	Coloured broiler
BW 08, wks (g) M	723.8 ± 14.68	1662 ± 26.96
F	590.9 ± 10.12	1516 ± 17.25
BW 20, wks (kg) M	1.904± 0.023	3.860 ± 0.021
F	1.681 ± 0.013	3.467 ± 0.020
AFE (days)	151.00	147.00
EP 40, wks (Nos)	44.11	-
EW 40, wks (g)	57.09 ± 0.45	64.54 ± 0.57

Development of rural chicken variety

The aim was to devleop a dual purpose chicken variety suitable for Tripura and adjoining areas. Different types of crosses were generated for development of new variety by using selected birds from local black germplasm. The following crosses were produced and evaluated.

Gramapriya ♂ (GM) × Deshi black ♀ (DF)

Deshi black ♂ (DM) × Gramapriya ♀ (GF)

BN Cross (50%)

Evaluation of Performance of two way crosses

Chicks of newly developed crosses were evaluated at farm and also given to farmers of different villages of Tripura for their evaluation under field condition (Table 147).

Table 147. Mean Performance of newly developed crosses at the institute farm

Traits	DG Cross (50%)	GD Cross (50%)	BN Cross (50%)
BW 08, wks (g) M	551.5 ± 11.21	564.9 ± 14.19	764.3 ±15.69
F	423.4 ± 10.34	440.2 ± 10.27	719.2 ±10.58
BW 20, wks (kg) M	1.635 ± 0.011	1.349 ± 0.020	2.024 ±0.045
F	1.107 ± 0.024	1.089 0.018	1.851 ±0.026
BW 40, wks (kg) M	2.416 0.045	2.433 0.073	-
F	1.770 0.040	1.692 0.034	
AFE (days)	145.00	152.00	151.00
EP 40, wks (Nos)	51.78	57.11	38.81
EW 40, wks (g)	54.25 ± 0.44	55.73 0.54	60.63±0.37


Figure 19: Female and Male birds of BN cross at the ICAR Tripura Centre

Development of three way cross chicken

Location specific variety BND Cross chicken (Dual type chicken) has been developed for Tripura by crossing of Coloured Broiler, Tripura Black and Dahlem Red. Genetic composition of newly developed dual variety chicken is Coloured Broiler (25%), Tripura Black (25%) and Dahlem Red (50%). BND Cross chicken is coloured bird with moderate body weight, good escaping ability and scavenging habits and suitable for rural backyard poultry farming in NEH Region. More than 50,000 chicks of BND Cross chicken have been distributed to farmers in different areas of the state. Two evaluation of mean performance of BND Cross chicken have been completed at farms and farmers fields and third evaluation is in progress.

Figure 20: Adult birds of Tokbari Chicken

Performance evaluation of Tokbari

Dual variety chicken (BND Cross) was developed at Division of Poultry Science, ICAR, Tripura Centre by crossing of Coloured Broiler, Tripura Black and Dahlem Red. Second evaluation of mean performance of dual variety chicken (BND Cross) is completed at institute farm as well as the field conditions (Tables 148 and 149).

Table 148. On – farm performance evaluation of Tokbari (Dual type) birds

Batch		First evaluation		Second evaluation	
Body weight		N	Average value	N	Average value
BW 0 day (g)		240	39.40	243	37.57
BW 4, wks (g)		214	236.65	229	234.5
BW 8, wks (g)		208	565.04	222	499.2
BW 12, wks (g)		111	1020	220	981.7
BW 20, wks (g)	Male	41	2043	77	1923
	Female	61	1563	132	1497
BW 40, wks (g)	Male	40	2692	48	2514
	Female	57	1889	91	1814
SL 6, wks (cm)	Male	40	8.60	46	9.30
	Female	50	6.53	75	7.79
ASM (days)					

Batch	First evaluation		Second evaluation	
AFE (days)	61	138	124	133
Age at 50% of egg production (days)	60	160	115	156
EW 40, wks (g)	53	53.20	85	52.50
EP 40, wks (Nos)	57	50.24	91	52.50
EP 52, wks (Nos)	55	89.90	75	94.80
EP 72, wks (Nos)	55	141.03	71	162.30

Table 149. Field performance evaluation of Tokbari (Dual type) poultry birds

Batch		First evaluation (61 farmers)		Second evaluation (50 farmers)	
Body weight		N	Average value	N	Average value
BW 4, wks (g)			242.6	520	242.5
BW 8, wks (g)			503.0	362	403.0
BW 12, wks (g)		306	840.0	311	864.6
BW 20, wks (g)	Male	107	1930	93	1821
	Female	187	1403	152	1378
BW 40, wks (g)	Male	94	2386	71	2203
	Female	179	1580	144	1580
AFE (days)			146	135	143
Age at 50% of egg production (days)			172	103	168
EW 40, wks (g)			48.11	96	47.30
EP 40, wks (Nos)			40.84	124	43.90
EP 52, wks (Nos)			74.05	101	82.75
EP 72, wks (Nos)			119.0	95	133.5

Impact of Tokbari (BND Cross) variety

Agriculture, livestock and poultry production is the main livelihood source for most of the farmers of Tripura. Rural Poultry Farming (RPF) implies rearing of poultry in small numbers in the backyard in the free range or in semi intensive system. Nearly 80% population of poultry consist of deshi/nondescript, in which growth and production is very low (50-60 eggs per bird per annum, 1.0-1.5 kg). So, farmers were supported for their livelihood by dissemination of newly developed variety BND Cross for backyard poultry farming. Each year improved varieties (BND Cross) of chicks were hatched in the hatchery of the Division of Poultry Science of the ICAR Tripura Centre, Lembucherra. The chicks were reared upto 4 weeks of age at the farm. After 4 wks of age, 10-20 chicks were given to each farmer. The performance of Toqbari under field condition and its economics are presented in Table 150.

Table 150. Parameters studied before and after introduction of back yard chicken

Particulars	Before	After
No. of house hold	Nil	325 (12 birds/farmer)
Variety introduced	Nil	Backyard poultry- CARI Nirbheek, Gramapriya
Production	60-70 eggs	160-180 eggs 2.0 kg (Adult body weight)
Increase in production	NA	Approx. 100 eggs /year
Total cost involvement (Rs.)	75/-	310/- bird
Gross Income (Rs.)	350/- bird	1050/- bird
Profit/ loss:	275/-	740/-
Increase in income (%)	--	338.7
Increase in employment (%)	--	20

Distribution of Tokbari chicks

Training to the farmers on backyard poultry farming

Tokbari birds in the farmers field

Tribal women with eggs of Tokbari chicken

Figure 21: Distribution and rearing of Tokbari chicken in Tripura

A total of 2.53 lakhs of improved chicken germplasm was distributed to the farmers of Tripura and adjoining states. Total revenue generated was Rs. 95.16 Lakhs from the Centre.

11 CSK Himachal Pradesh Krishi Viswavidhyalay, Palampur

AICRP on poultry breeding (Rural poultry Unit), Palampur was established during March, 2009 to strengthen the rural poultry in Himachal Pradesh. The mandate of the centre is to characterize, and evaluate native local chicken populations and also to develop location-specific chicken variety suitable for hill ecosystem of the state. Promotion and propagation of the rural poultry farming is another activity of the centre.

Since 2009, infrastructure development, strengthening of facilities and procurement, multiplication and propagation of poultry germplasm were undertaken at the centre.

Achievements

Construction of Poultry hatchery (by modification of existing building in department) and construction of an additional new building for providing 28 mating pens for planned pedigree breeding was completed (2012). New brooder-cum-grower house (2017) and feed store (2018) were constructed. Construction of an additional layer house (2019) is under process. Purchase of major incubation equipments and machinery (setter, incubator and generator, feeders, waterers etc.) was completed in 2010. As per requirements and budgetary provisions, new equipments are being purchased from time to time. New set of egg-incubator and hatcher were procured during the year 2017. Purchase of cold chamber/construction of cooling room is under process. The performance of different purelines (Vanaraja, RIR, DR and Native) was evaluated earlier at farm level. Different crosses were produced and evaluated at farm and/ or field level and propagated at farmer's level to promote backyard poultry production. Surveys to identify farmer's preference for type of stock desired for backyard poultry farming in local areas. The farmer's choice was for a dual purpose colored bird.

A location specific dual- purpose poultry variety Himsamridhi suitable to backyard poultry farming in hilly areas was developed. The developed variety is being propagated for improvement of village poultry farming in different agro-climatic regions of the state. Linkage was established with NGOs (CORD, Sidhbari and RTDC), a SHG and KVKs for establishment of Poultry units and skill upgradation of farmers. Skill development: 240 contact hrs training on job role "Small Poultry Farmer" sponsored by Agricultural Skill Council of India (ASCI) was organized in collaboration with Deptt. of Veterinary & AH Extension Education. Organized two training programs under Micro Entrepreneur Development Program (MEDP) of NABARD in collaboration with CORD Training Center. 10 one-day poultry farmer awareness campaigns were organized for NGOs (CORD NGO at Dharamshala and RTDC NGO at Baijnath). The participants were females of different SHG's of respective NGO who were actively engaged in backyard poultry farming. A total of 2,24,757 chicks have been distributed to poultry farmers in different districts of Himachal Pradesh. The centre is currently maintaining a selected improved Native / Desi bird population with G-6 and G-7 generation of the stock now under evaluation. The Native/ Desi birds have shown continual improvement for growth and production traits over the generations.

The following technical program was followed to develop egg type chicken variety.

Breeding plan for production of egg type chicken stock

Improved egg type stock, DR (♂) X Local Native (♀)

↓

F1 (50% improved germplasm + 50% Native germplasm)

Evaluation of F1 ↓

F1 (♂) X DR (♀)

↓

F2 (Terminal crosses; 75% DR + 25% Local Native)

Evaluation under farm and field conditions

↓

Propagation of (DR X N) X DR (F2)chicks to farmers

Selection criterion for native birds: Local native chicken are selected on the basis of their phenotypic performance and egg production up to 40 weeks with similar phenotypic appearance

Male

Female

Native birds

Male

Female

Himsamridhi

Figure 22: Native and Himsamridhi birds in Himachal Pradesh

Phenotypic time trend was estimated for Native birds and Dahlem Red produced through selective breeding, maintained at Poultry Farm, Palampur (Table 151).

Table 151. Phenotypic trend for various traits in native and Dahlem Red birds

Trait	Phenotypic trend		Trait	Phenotypic trend	
Body Weight (g)	Native	Dahlem Red		Native	Dahlem Red
Day old	0.70	-0.89	HHEP (Nos)		
BW 4, wks		17.58	EP 40	3.1	4.79
BW 8, wks		56.35	EP 52	4.6	15.83
BW 12, wks		133.5	EP 72	1.7	31.6
BW 20, wks	25.01	-37.99	HDEP (Nos)		
BW 40, wks	-53.45	-141.2	EP 40	3.8	1.93
Egg Weight (g)			EP 52	6.1	8.31
EW 28, wks	2.1	-1.7	EP 72	2.3	13.98
EW 40, wks	1.5	-3.3	SEP (Nos)		
EW 52, wks	0.4	-2.3	EP 40	4.2	1.56
AFE (days)	-4.8	5.5	EP 52	7.7	2.06
			EP 72	2.3	-17.37

Varieties developed

A location specific dual- purpose poultry variety "*Himsamridhi"* suitable to backyard poultry farming in Hilly areas was developed and released during Annual Review Meet of AICRP on Poultry Breeding and Poultry Seed Projects held at CSKHPKV, Palampur on May 24-25, 2017.The variety developed under AICRP on poultry breeding was extensively evaluated both under farm and field conditions with satisfactory performance, adaptability and farmer-acceptability under local agro-climatic conditions. The birds of developed "*Himsamridhi"* variety are similar to native birds in appearance and plumage colour. These birds demonstrated comparatively better growth than native (Male 1.4-1.7 kg and Female 1.2-1.6 kg at 20 weeks; Male 2.0-2.4 kg and Female 1.5-1.7 kg at 40 weeks) at farmer's flock. *Himsamridhi* birds mature early (180 days), lay larger eggs (50-55g) with annual egg production of 130-140 eggs/bird under farmer's field and 160-180 eggs/ bird under farm conditions. There is huge demand for these birds because of their ability to provide good economic returns as compared to other birds under similar inputs and rearing practices.

Impact of the technologies/varieties developed:

Location specific poultry variety "*Himsamridhi*" developed and is propagated for improvement of village poultry farming in different agro-climatic regions of state for improvement in the nutritional status and livelihood security of the farmers. Tribal component of project ensures the availability of chick and promotion of backyard poultry in the far flung tribal region of high hills. Earlier due to environment and institutional constraint good quality LIT birds were not available to farmers. During last 3 years, 636 Tribal poultry units were established and 33,892 chicks were distributed in three tribal districts of the state under the TSP component of AICRP on Poultry breeding. The establishment of tribal poultry units not only resulted in the propagation of poultry in this region but also ensured supply of good quality protein in terms of egg and poultry during winters in the tribal regions. Organization of exposure visit/training programme/skill development programme with different NGOs and institution resulted in better managerial skills of rural poultry farmers and SHGs of youth and women farmers of different NGOs are ready to take up small scale poultry farmer at group level. Effective linkages have already been established with NGOs (CORD and RTDC) to include backyard poultry in their village development initiative. Every year, two to three training programmes are being organized in coordination with different NGOs

A total of 3.97 lakh chicks of different stocks have been distributed to farmers in different district of Himachal Pradesh. A sum of Rs. 110.72 lakhs was generated as revenue through sale of eggs, poultry meat and manure. A total of 3056 farming families benefitted in Himachal Pradesh with backyard poultry farming. About 6 success stories were documented on Himsamridhi farming in Himachal Hill ego system.

12 Birsa Agricultural University, Ranchi

AICRP on Poultry Breeding was started on 23rd March, 2009 at BAU, Ranchi. Jharkand with an aim to popularize backyard poultry and to develop location specific chiken varieties for the benefit of tribal populaiton of Jharkand.

Achievements

During the year 2009-10, survey was conducted in the three regions of Jharkhand i.e. Chhotanagpur, Santhal Pragna and Kolhan region to know the type of birds liked by the farmers and it was found that dual type birds were the preferred ones. The local germplasm in the nearby area of Ranchi, Bundu, Tamar and Sonahatu was procured and is being evaluated. The centre evaluated PB-2 Male line variety developed by DPR. Sixth evaluation was completed in 2017-18. The centre is also evaluating Dahlem Red variety from CARI, Izzatnagar and at present, G-7 generation is under evaluation. The centre is working on development of new varieties suitable for rural poultry for Jharkhand utilizing local germplasm and other chicken germplasm procured from different ICAR institutes. The centre evaluated PB-2 Male line variety developed by DPR and Dahlem Red variety from CARI, Izzatnagar. These improved lines were crossed with native and the resulting two-way and three-way crosses were evaluated. As a result, a new dual type variety named *"Jharsim"* was developed and released on 11.04.2016.

Evaluation of pure line and crosses

Native

Evaluation of local germplasm was initiated by purchasing birds from local farmers. A flock of brown/black mix plumage colour having uniformity in colour and other physical traits were generated and evaluated for six generations. The average fertility was 86.42% and average percentage hatchability on TES and FES were 68.42% and 78.78% respectively which has improved considerably from first to sixth generation. The mean body weight was measured from day old to 20 weeks with an interval of 4 weeks. The mean body weight at day old, 4, 8 weeks was 28.14±0.25, 162.6±1.55 and 360.6±2.11 g respectively. The mean body weight at 12 and 20 weeks of age were 989.20 and 1385.17± 9.22 g in male and 760.95±2.60 and 1169.27±2.85 g in female, respectively. The age at first egg was 182 days and weight of first egg was 38 g. The body weight of the female at first lay was 1217±8.16 g, egg weight at 40th week was 42.40±0.39 g. The average egg production at 40th week of age on HD basis and HH basis was 32.33% and 30.71%, respectively.

Evaluation of improved germplasm

Dahlem Red

The 6th generation Dahlem Red parent line was evaluated at farm. The body weight of Dahlem Red (G6) was recorded from 0 to 20 at 4 weeks interval at farm. The body weight at 0,4,8,12 and 16 weeks of age were 34.98±1.52, 175.6±1.02, 429.1±2.90, 816.9±3.75, 1219±3.93 g, respectively. The 20 weeks body weight was 1717±9.12 g in male and 1509±3.67 in female. During the year 2016-17, the fertility was 88.59%. The percent hatchability on total and Fertile egg set basis was 69.15% and 78.06 % respectively. The age at first lay was 155 days. Egg weight at 40th week was 49.48±0.52 g. The average egg production at 40th week of age on HD basis and HH basis was 45.38 and 45.38, respectively.

PB-2

These are the broiler line birds brought from Directorate of Poultry Research, Hyderabad and evaluated up to 20 weeks of age. For G-7 groups, males weighed about 2206± 8.28 g.

Evaluation of crosses

Two-way crosses and three-way crosses were generated using selected birds from local germplasm. Female birds were selected on the basis of physical appearance while males were selected based on higher body weight and shank length. The crosses were generated and evaluated for the performance:

Two way cross (PB-2 x Native)

The evaluation of BN cross upto fifth generation has been completed. The production performance of E4 evaluation has been completed. The 6th BN cross evaluation is going on at Farm. The body weight has been recorded as 33.08±0.24 g, 186.1±1.40 g, 508.5±3.69 g, 1005.6±5.49 g, 1588±7.30 g, (Male) 2206±15.99 and (Female) 1801±8.28 at 0 day, 4th, 8th, 12th and 16th and 20th weeks of age, respectively. The age at first lay of the flock was 163 days, weight of egg at 40th week was 48.10±0.40 g. Fertility percentage was 90.71% while the hatchability % was 70.71% and 77.95% on TES and FES basis respectively. The average egg production at 40th, 52nd and 64th week of age on HD basis and HH basis was 32.24 and 31.43, 69.13 and 66.53, 90.92 and 87.51 eggs, respectively.

Jharsim

Jharsim, location specific chicken variety was developed using synthetic broiler (25%) native (25%) and Dahlem Red (50%) Inheretance the 2 way F1 males were crossed Dahlem Red females to produce Jharsim. Jharsim birds were evaluated under farm conditions. The growth and production performance evaluation of Jharsim up to E4 has been completed at farm and villages and E5 and E6 evaluation is going on at farm. The body weight has been recorded as 29.70±0.19 g, 183.4±1.11 g, 535.3±4.48 g, 839.2±5.04 g and 1149±5.35 g at 0 day, 4th, 8th, 12th and 16th weeks of age, respectively. The age at first lay of the flock (E5) was 170 days. Egg weight (g) at 40th week was 51.16±0.50. The average egg production at 40th, 52nd and 64th week of age on HD basis and HH basis was 36.45 and 35.47, 71.32 and 67.48 & 101.42 and 95.94, respectively.

The comparative evaluation of pure line and three-way cross for growth and production traits is presented in Table 152.

Figure 23: Jharsim birds in farmers fields

In April 11, 2016, Birsa Agricultural University (BAU) unveiled Jharsim a new dual type variety of chicken for backyard poultry farming that lays brown eggs.

Salient feature of Jharsim

- Attractive multicolour feathers as tribal people of Jharkhand like coloured birds from religious point of view. Coloured plumage can protect themselves from predators.
- Perform on low plane of nutrition.
- Longer shank length which helps in self-protection from predators in backyard areas.
- Good adaptability in backyard/ free range.
- Grows faster and produces more no of eggs than Desi hen.
- Produces brown eggs like Desi hen.
- Broody character is noticed in some hens.
- Body weight at 20 weeks of age ranged from 1.5 to 2 kg for males and 1.4 to 1.6 kg for females.
- Higher egg production of 132-140 eggs which is two times more than the local native birds (50-60 eggs).

Table 152. Evaluation of Pure line and three way cross growth and production performance

Body weight (g)	Native	Dahlem Red	PB-2	PB-2 x Native	Jharsim
day old	29.80 ± 10.53	32.05 ± 11.33	33.33±11.78	28.56 ± 10.10	31.05 ± 10.98
BW 4, wks	169.0 ± 59.76	183.40 ± 64.84	317.11 ± 112.1	171.77 ± 60.73	182.56 ± 64.54
BW 8, wks	418.8 ± 148.0	466.16 ± 164.8	807.55 ± 285.5	457.57 ± 161.8	547.25 ± 193.5
BW 12, wks	745.6 ± 263.6	815.04 ± 288.1	1293.67 ± 457.4	713.80 ±252.3	861.50 ± 304.6
BW 16, wks	1010 ± 356.9	1139.20 ± 402.8	1799.01 ± 636.0	925.10 ±327.0	1218.21 ± 430.8
BW 20, wks M	1433 ± 506.7	1652.69 ± 584.3	2563.45± 906.3	1329.62±470.1	1706.19 ±603.2
F	1179 ± 416.8	1423.02 ± 503.1	2220.09 ± 784.9	1113.47±393.7	1430.57 ± 505.9
Egg weight (g)					
EW 40, wks	41.26 ± 1.25	47.31±1.08	-	44.85±1.12	45.14 ±1.42
AFE (d)	175.3±1.70	156.71±2.65	-	160.25 ± 2.56	165.17±2.32
Egg production (Nos)					
EP 40, wks HD	31.15±0.80	40.58±2.44	-	33.58±3.38	35.58±1.53
HH	29.98±0.77	38.15±3.06		32.53±2.84	33.59±1.80
EP 52, wks HD	55.59±3.22	81.18±7.85	-	66.71±3.65	75.80±7.23
HH	52.92±3.02	77.73±8.24		63.62±2.88	69.97±6.71
EP 60, wks HD	66.79±2.92	108.32±16.85	-	84.67±1.58	91.87±0.38
HH	63.22±2.64	104.12±17.38		78.05±1.27	83.01±1.73
EP 72, wks HD	78.37±1.84	-	-	104.97±0.70	152.90±13.08
HH	72.83±1.68			97.97±3.77	134.90±11.00

Impact of Jharsim in backyard system in Jharkhand and Bihar

The input and output of Jharsim birds were evaluated at Jahanabad KVK (Bihar) and FFP project at Nagri village (Jharkhand). A total of 320 birds (8 weeks old) among 32 farmers and 250 (8 weeks old) birds among 25 farmers were distributed respectively. In Jahanabad, mortality of 10.93% was reported up to 60 weeks of age, age at first egg was 174 days, female birds laid 132 eggs up to 60 weeks of age and males weighed 3.5 kg body weight during the period. Gross production cost on feed, medicine, vaccine etc. Was Rs. 1,13,160/- and gross return by sale of eggs and birds was Rs. 4,28,560/- and net return was Rs.3,15,400/- and the BC ratio was 3.76. net return per farmer was Rs. 9,856/-. Whereas in Nagri village (Jharkhand) the mortality was 7.2% up to 60 weeks of age, 195 female birds laid 135 eggs in 60 weeks of age and male weighs 3.2 kg body weight up to 60 weeks of age. Gross production cost on feed, medicine, vaccine etc, was Rs. 96,500/- and net return by sale of egg (@Rs. 7/-) and birds (@Rs. 190/kg) and net return was Rs. 2,19,775/- and the BC ratio 3.2. net return per farmer was Rs.8,791/-

The centre has supplied 2.3 lakh chicks to the farmers, NGOs, KVKs and other agencies with a revenue of Rs. 61.40 lakhs. A total of 684 farmers benifitted with backyard poultry in Jharkand. About 2374 farmers from different districts of Jharkhand have been provided individual and group training for 10 days on poultry production and management.

13 Maharana Pratap Agricultural University of Agriculture and Technology, Udaipur

The centre started on 19th July, 2009 with an aim to characterize and evaluate native chicken germplasm and also to develop location-specific chicken varieties suitable for Rajasthan and adjoining areas. In the beginning of the project, during 2009-10, a survey was conducted on 300 poultry keepers belonging to 12 tehsils from 6 districts of Rajasthan to know the choice of the bird. The first choice of poultry keepers was dual type in the rural areas while egg type in urban areas and meat type bird was the third choice of the farmers. Based on results of survey, the technical programme for development of dual type chicken was followed for the centre.

Achievements

Varieties developed

The "BNR" (Broiler X Native) X RIR, a dual purpose three-way cross named Pratapdhan was developed at this centre for rural poultry farming and was released for distribution to farmers in the XXX Annual Review Meeting of AICRP on Poultry Breeding and Poultry Seed Project held at MPUAT, Udaipur on 9-10, September, 2012. Since then, the centre is engaged in production and supply of Pratapdhan chicks to the farmers. There is huge demand for Pratapdhan chicks in the state as well as outside the state. The centre has also worked on development of egg type bird (RNR), but the production performance of the bird was at par with Pratapdhan and slightly lower in body weight. Also, due to ever increasing demand of Pratapdhan, the centre continued with Pratapdhan. Development of a meat type bird for rural poultry production was also proposed to be included in the technical programme for the centre.

Salient features of Pratapdhan

- Attractive multicolour feather pattern
- Longer shank length
- Good adaptability in backyard/ free-range
- Produces brown shell egg.
- Has broody characteristic.
- Fast growth rate and higher egg production (161) than native

The performance of Pratapdhan has been evaluated vis-à-vis Desi chicken is presented in Table 153.

Table 153. Comparative performance of native and Pratapdhan chicken under field conditions

Traits		Breed		% higher
		Native	Pratapdhan	
BW 20 (kg)	Male	1.3	1.8	38
	Female	1.0	1.6	60
	Pooled	1.1	1.7	55
BW 40 (kg)	Male	1.6	2.1	31
	Female	1.4	2.0	43
	Pooled	1.5	2.0	33
ASM (days)		181	157	13
Annual egg production (Nos)		43	147	242

Body weight of Pratapdhan birds under field conditions is higher by 38-60 % at 20 wks and 31-43 % at 40 wks than the deshi fowl. Similarly, the egg production of Pratapdhan is 242 % higher than the native fowl maintained by the farmers in Rajasthan. The age at sexual maturity of Pratapdhan is 13% lower than the deshi chicken. The performance of Pratapdhan birds has been detailed in Tables 153-155.

Impact of technology developed

Traditionally farmers rear birds under backyard system with zero inputs with only 10-20 native/ *deshi* birds. A mere shift from native to improved germplasm has led to a quantum increase in the returns for the farmers with same rearing practices. Looking to the better performance and profitability of the Pratapdhan birds, there is a huge demand of this breed. Farmers are now gradually increasing the flock size, paying attention on housing and feeding of birds and poultry rearing contributing substantially to their subsidiary income. The economics of rearing a unit of 20 chicks was calculated as per information provided by farmers considering cost of chick Rs 65/ chick, mortality 10%, sale price of meat and egg Rs 200/ kg live weight and Rs 10/ egg. The performance and economics Pratapdhan chicken are presented in Tables 156 and 157, respectively.

- The farmer earns on an average annual net profit of Rs 20070 by keeping a unit of 20 Pratapdhan birds which is Rs 11340 more than what he gets by keeping native non-descript birds.
- About 20000 farmers were supplied chicks, considering the number of farmers benefitted (unit of 20 chicks per farmer) since September 2012, the egg production is expected to increase (147 vs 43 eggs) to the tune of 1.87 crore eggs which will fetch an additional sum of Rs 18.7 crore. Considering the sale price of Rs 200 / kg live weight, the income generated from sale of birds is expected to increase by Rs 4.00 crore. Thus, a mere change of germplasm from native birds to Pratapdhan has accumulated an additional wealth of about 22.7 crore to the farmers.
- Backyard farming plays a significant role in rural people's life and alleviated protein malnutrition of women, feeding mothers, children and sick. The increased egg and meat production by keeping Pratapdhan would certainly help in enhancing consumption of egg and meat by the family members, especially women, feeding mothers and children, thus, ensuring nutritional security of farming households.

Table 154. Production performance in Pratapdhan

Particulars	Generations						
	E1	E2	E3	E4	E5	E6	E7
AFE (days)	125.00	128	124	133	127	138	134
ASM (days)	169.59±2.47	147±0.99	143.10±1.59	151.27± 1.41	144.54± 0.55	157.61±0.78	157.61±0.78
n	75	236	125	132	154	149	149
EW 28 (g)	46.88±0.35	49.41±0.15	48.62±0.47	47.06±0.19	47.13±0.18	47.70±0.22	47.27 ± 0.27
n	309	1040	92	105	307	433	391
EW 40, wks (g)		53.84±0.20	52.91±0.52	52.85±0.13	53.79±0.11	53.13±0.31	52.57±0.21
n		416	107	84	305	265	265
HDEP 40, wks (Nos)	67.44	72.31	55.30	51.24	80.86	65.17	62.26
HHEP 40, wks (Nos)	47.14	61.66	31.44	38.08	62.91	49.91	52.35
HDEP 52, wks (Nos)	93.63	97.31	83.68	86.41	108.01	103.10	100.42
HHEP 52, wks (Nos)	58.85	79.56	40.92	55.17	75.59	74.57	72.34
HDEP 72, wks (Nos)	161.16	165.65	160.90	159.12	170.89	167.51	166.10
HHEP 72, wks (Nos)	76.72	101.40	53.91	80.15	96.29	100.25	100.28

Table 155. Body weight of Pratapdhan at different ages under field condition

Traits	Male	Female	Pooled
BW 0 day (g)	36.10 ± 0.20	35.50 ± 0.22	35.72 ± 0.14
BW 2, wks (g)	161.5 ± 2.20	160.9 ± 2.06	160.3 ± 1.47
BW 4, wks (g)	305.6 ± 3.20	276.4 ± 2.66	291.6 ± 2.17
BW 8, wks (g)	662.5 ±9.10	655.3 ± 7.82	658.4 ± 5.97
BW 20, wks (g)	1816 ± 22.70	1612 ± 12.84	1706 ± 13.02
BW 40, wks (g)	2072 ± 30.10	2009 ± 21.25	2032 ± 17.45

Table 156. Productive performance of Pratapdhan under field condition

Traits	Values
AFE (days)	157
Age at 50% egg production (days)	232
EW 28, wks (g)	48.23±0.60
EW 40, wks (g)	55.19±0.48
HDEP 40, wks (Nos)	50.56
HHEP 40, wks (Nos)	49.40
SEP 40, wks (Nos)	52.92
HDEP 52, wks (Nos)	85.91
HHEP 52, wks (Nos)	82.12
SEP 52, wks (Nos)	90.39
HDEP 72, wks (Nos)	147.34
HHEP 72, wks (Nos)	133.62
SEP 72, wks (Nos)	194.76

Table 157. Economic comparison between native and Pratapdhan chicken in the field (a unit of 20 chicks)

Income from sale of produce (Rs.)	Native	Pratapdhan
Males	2340	3240
Eggs	3870	13230
Female	2520	3600
Total	8730	20070
Profit / unit (Rs)	7030	18370
Net profit (Rs.)	11340	

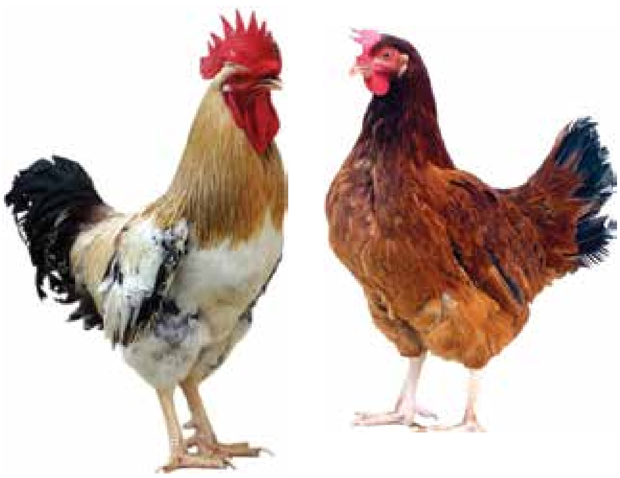


Figure 24: A pair of Pratapdhan birds

Mewari chicken

Local native germplasm was registered as *Mewari Chicken*, new indigenous chicken breed of India with accession number, India_chicken_1700_mewari_12016

AICRP centre, MPUAT, Udaipur, has registered a new indigenous breed of chicken. The home tract is Udaipur, Bhilwara, Dungurpur, Banswara, Rajasamand, Chittorgarn, Pratapgarh districts of Rajasthan. Mewari is reared for egg and meat under free range or scavenging system.

Salient Features

- Attractive multicolour feather pattern
- Moderate shank length and strong wings
- Survive completely on free range or scavenging system
- Produce creamy to brown shell egg of medium size
- Has broody characteristic

Physical Characteristics

- Plumage colour varied from light to dark brown and grey with pencil linings in females and bright gold and bronze feathers forming a shawl or cap over neck in males
- Yellow coloured skin and shank with red earlobe and comb
- Single comb of medium size in females and medium to large size in males with large and red wattles

Growth and Production characteristics: The growth and production characteristics of Mewari breed of chicken have been outlined in Tables 158 and 159.

- Adult body weight ranged between 1.09 to 1.47 kg in females and 1.67 to 2.29 kg in males in the native tract.
- Age at first egg varied from 6 to 7.5 months under field conditions.
- Annual egg production ranged between 37 to 52 eggs.
- Clutch size and clutch interval ranged between 10 to 15 and 102 to 117 days under field conditions.

Figure 25: A pair of Mewari birds

Table 158. Growth performance of Mewari

Trait	Body weight (g)		
	Male	Female	Pooled
BW 0 day	31.27± 0.10	31.41± 0.07	31.36± 0.06
BW 2, wks	118.02± 0.59	114.46± 0.49	116.0± 0.38
BW 4, wks	254.6± 2.65	206.3± 2.18	227.6± 1.80
BW 8, wks	676.3± 5.71	618.6± 3.73	629.7± 3.21
BW 20, wks	1715± 16.95	1329± 7.82	1436± 9.40
BW 40, wks	2287± 32.08	1460± 9.17	1670± 21.53

Table 159. Production performance of Mewari

Particulars	G-0	G-1	G-2	G-3	G-4	G-5	G-6	G-7
AFE (days)	142	140	132	138	129	143	148	150
ASM (days)	181.2±3.85	187.5 ±1.23	156	164	170.4	174.73	171.6	159.31
EW, wks 28 (g)	36.61±0.29	41.88±0.25	43.15±0.20	42.42±0.37	41.10±0.19	41.86 ± 0.14	41.26 ± 0.20	42,36 ± 0.16
EW, wks 40 (g)	42.59±0.37	48.04±0.23	48.40±0.22	46.52±0.35	45.47±0.18	45.98±0.12	45.24 ± 0.20	46.19 ± 0.18
HDEP 40, wks (Nos)	28.93	31.76	47.18	41.57	29.42	46.92	44.89	41.26
HHEP 40, wks (Nos)	21.22	21.94	37.74	30.54	43.86	28.81	30.35	28.94
HDEP 52, wks (Nos)	59.87	59.89	70.76	54.95	72.17	70.58	65.07	67.34
HHEP 52, wks (Nos)	40.36	37.37	50.56	71.67	112.11	39.96	38.88	37.26
HDEP 72, wks (Nos)		92.76	-	93.41	95.09	92.92	96.58	98.22
HHEP 72, wks (Nos)		55.24	-	97.39	73.14	54.96	49.75	43.40

The centre has supplied about 7.55 lakh germplasm in the form of chicks, growers and hatching eggs since inception of the project. Pratapdhan developed under the project has significantly higher adoption rate in the field which is evident from ever increasing demand for the bird. Since the inception of the project, the revenue generated is to the tune of Rs. 157.82 lakhs. About 20000 farmers were benefitted by the supply of chicks and other inputs. The chicks were supplied in almost all districts of Rajasthan and also other states namely Madhya Pradesh, Gujarat, Maharashtra, Haryana, Punjab and Jammu and Kashmir. About 1600 tribal farmers were also benefitted by the activities under TSP component of the project. Under TSP component of the project, farmers were distributed chicks (about 27000 chicks) and other poultry inputs such as feeders, waterers, feed etc. They were also trained in rearing of Pratapdhan through about 30 on and off campus trainings.

14 Assam Agricultural University, Guwahati

The ICAR-AICRP on Poultry Breeding, AAU, Guwahati centre was established on 18th May, 2009 with the mandate to develop a dual type of chicken incorporating native germplasm as per the choice of rural farmers of Assam.

Initially Indigenous chicken is procured from different parts of Assam and selected for the desired traits. The selected female of indigenous chicken is crossed with the male of PB-2 procured from ICAR-Directorate of Poultry Research, Hyderabad. The F1 male is crossed with Dahlem Red female which was procured from DPR, Hyderabad. This three-way cross is studied in farm and field condition and found satisfactory for different traits and later on named as "Kamrupa" and released on 11th February, 2015 by Hon'ble DDG(AS), ICAR, New Delhi in presence of Hon'ble Vice-Chancellor, Assam Agricultural University, Jorhat, Assam, faculty members and farmers. Now the improvement of Kamrupa chicken and production of Kamrupa hatching egg and DOC is going on and sold to the farmers, NGO, Entrepreneurs and KVKs of Assam and NE region.

Achievements

Genetic evaluation of growth, production and reproduction traits were evaluated in native and Kamarupa birds in addition to the parental lines of Kamarupa chicken (Tables 160 - 163).

Table 160. Growth and conformatory traits in native chicken of Assam

Year	Body weight, g		Coformation traits at 5 wks			FCR up to 5 wks
	0 day	5 wks	Shank length, mm	Breast Angle, degree	Keel length mm	
2009-10	25.91 ± 2.50	92.30 ± 2.90	42.30 ± 2.60	53.40 ± 2.90	45.60 ± 2.90	-
2010-11	26.40 ± 1.90	98.75 ± 3.65	44.32 ± 2.10	55.21 ± 3.60	44.58 ± 2.60	3.50
2011-12	26.60 ± 2.10	96.40 ± 3.10	45.60 ± 2.80	55.80 ± 2.90	45.10 ± 2.30	3.40
2012-13	26.89 ± 1.80	99.33 ± 2.60	46.20 ± 3.16	58.12 ± 6.20	47.32 ± 3.50	3.52
2013-14	28.30 ± 2.57	102.6 ± 5.86	45.31 ± 1.52	56.56 ± 2.01	48.52 ± 1.68	3.39
2014-15	28.90 ± 3.20	105.6 ± 6.16	46.23 ± 1.73	55.48 ± 1.96	49.25 ± 1.82	3.35
2015-16	29.50 ± 2.90	115.9 ± 5.85	46.56 ± 1.21	56.36 ± 2.50	49.76 ± 2.20	3.31
2016-17	30.16 ± 2.45	118.1 ± 6.10	46.82 ± 1.56	57.20 ± 3.12	49.33 ± 2.29	3.29
2017-18	31.70 ± 2.85	126.6 ± 7.20	47.20 ± 2.25	56.50 ± 4.10	50.25 ± 2.60	3.27
2018-19	33.90 ± 2.70	132.5 ± 6.90	48.10 ± 3.20	57.20 ± 5.20	51.10 ± 3.20	3.25
2019-20	34.80 ± 3.20	138.9 ± 7.20	48.70 ± 2.80	57.60 ±6.10	51.90 ± 2.70	3.23

Table 161. Body weight (g) and Age at sexual maturity (day) in indigenous chicken

Year	Body weight, g		ASM, d
2009-10	20 wks	40 wks	
2010-11	895.5 ± 10.15	1350 ± 190.60	186.00 ± 4.60
2011-12	892.6 ± 11.20	1355 ± 210.60	190.20 ± 5.20
2012-13	900.8 ± 41.30	1366 ± 120.65	184.35 ± 6.30
2013-14	905.5 ± 56.43	1399 ± 89.55	178.42 ± 5.11
2014-15	975.3 ± 61.25	1436 ± 94.30	181.62 ± 6.50
2015-16	995.6 ± 58.25	1486 ± 73.60	180.50 ± 7.30
2016-17	1005 ± 60.25	1506 ± 82.50	178.25 ± 6.90
2017-18	1091 ± 85.20	1580 ± 110.60	176.30 ± 5.85
2018-19	1131 ± 95.50	1610 ± 120.50	175.20 ± 6.20
2019-20	1251 ± 105.20	-	174.60 ± 5.90

Table 162. Egg production in indigenous chicken of Assam

Year	Egg production (Nos)						Egg weight (g)	
	40 wks (HH)	40 wks (HD)	40 wks (Survivor)	52 wks (HH)	52 wks (HD)	52 wks (Survivor)	40 wks	52 wks
2010-11	31.23	32.56	32.86	62.40	64.25	65.10	35.42 ± 1.90	42.23 ± 1.80
2011-12	32.61	32.92	33.44	63.20	65.52	66.23	35.97 ± 2.96	40.60 ± 2.10
2012-13	32.93	33.46	33.76	63.40	65.45	66.30	36.49 ± 3.10	37.50 ± 3.60
2013-14	34.12	35.69	34.92	63.40	65.45	66.30	35.92 ± 2.97	38.15 ± 2.56
2014-15	35.60	36.80	36.95	64.20	65.40	67.10	35.84 ± 2.90	39.10 ± 3.50
2015-16	35.85	37.10	37.45	64.50	65.90	67.30	36.10 ± 2.56	39.70 ± 4.25
2016-17	36.20	37.45	37.85	64.90	66.20	67.60	36.96 ± 2.43	39.85 ± 3.95
2017-18	37.80	39.10	39.80	66.85	68.40	70.20	36.50 ± 3.25	39.25 ± 4.10
2018-19	38.60	40.20	40.90	67.50	69.20	72.30	37.20 ± 4.60	40.30 ± 3.90
2019-20	39.20	41.30	41.30	-	-	-		

Table 163. Fertility, Hatchability and Mortality

Year	Fertility (%)	Hatchability (%) TES	Hatchability (%) FES	Mortality (%) (0-5weeks)	Mortality (%) (6-20 weeks)	Mortality (%) (21-40 weeks)	Mortality (%) (41-52 weeks)
2009-10	57.35	27.18	44.53	13.20	49.47	1.04	-
2010-11	78.10	46.98	60.18	15.96	8.51	6.12	2.53
2011-12	71.27	52.52	73.83	11.74	10.60	16.69	1.21
2012-13	71.31	44.58	62.52	23.42	15.55	13.84	2.00
2013-14	75.36	58.45	77.56	1.59	2.67	1.41	1.51
2014-15	75.21	59.01	78.44	2.47	1.01	0.29	0.36
2015-16	77.09	61.41	79.65	2.65	1.36	0.29	0.36
2016-17	76.98	60.92	79.14	2.62	1.69	0.29	0.07
2017-18	77.12	61.73	80.05	3.47	3.86	1.07	15.29
2018-19	78.33	63.58	81.16	2.12	2.48	1.27	0.96
2019-20	78.60	63.90	82.10	2.10	2.30	-	-

Development of Kamrupa

Kamrupa a dual purpose chicken variety developed for rural poultry farming. Kamrupa, a multi-coloured bird for rural poultry production developed under AICRP on Poultry Breeding at Assam Agriculture University, Khanapara, Guwahati, Assam (Figure 26). Kamrupa is a 3 way cross involving Native X PB-1 X DR. The indigenous females are crossed with PB-1 males to produce a 2 way cross. The F-1 males are again crossed with Dahlem Red females to produce 3 way cross. The performance of this three way cross had been tested in farm and field condition for the productive and reproductive traits. This variety can easily adapted to different environmental condition of Assam and other north eastern states. Under backyard system, the body weight of birds at 8 and 20 weeks is 500-650 g and 1.3-1.5 kg, respectively. The annual egg production of hens is 118-130 eggs with an egg weight of 52g. The data on different economic traits is presented in Table 164-169.

Table 164. Growth Performance of Kamarupa

Year	Body weight, g		Coformation traits			FCR up to 5 wks
	0 day	5 wks	SL 5, wks (mm)	BA 5, wks (°)	KL 5, wks (mm)	
2013-14	33.52 ± 2.91	175.5 ± 31.23	45.20 ± 2.92	65.31 ± 3.69	46.70 ± 3.56	2.86
2014-15	34.62 ± 2.50	178.6 ± 35.64	46.15 ± 2.60	64.50 ± 4.62	47.20 ± 4.25	2.81
2015-16	35.15 ± 2.90	210.3 ± 31.56	46.50 ± 2.90	64.90 ± 5.10	47.80 ± 4.60	2.80
2016-17	35.40 ± 2.80	220.4 ± 42.56	46.85 ± 2.80	65.20 ± 6.20	47.95 ± 5.10	2.75
2017-18	36.20 ± 2.90	230.6 ±51.20	47.20 ± 2.90	65.90 ±7.30	48.30 ± 6.20	2.73
2018-19	37.10 ± 2.70	250.5 ± 45.60	48.90 ± 3.20	67.20 ± 8.40	50.10 ± 7.20	2.71
2019-20	37.60 ± 3.20	260.3 ± 51.30	49.20 ± 4.60	67.60 ± 9.40	50.80 ±11.30	2.72

Table 165. Adult body weight and ASM in Kamrupa

Year	Body weight, g		ASM, d
	20 wks	40 wks	
2012-13	997.89 ± 121.56	1856.98 ± 234.56	153.25 ± 3.61
2013-14	1020.90 ± 129.24	1890.40 ± 261.25	151.25 ± 2.90
2014-15	1090.80 ± 135.26	1970.50 ± 310.56	152.60 ± 3.10
2015-16	1120.40 ± 165.25	1995.60 ± 415.50	150.65 ± 4.50
2016-17	1150.30 ±170.60	2010.30 ± 390.30	151.30 ±5.30
2017-18	1210.40 ± 160.50	2140.40 ± 430.60	150.60 ± 4.90
2018-19	1240.30 ± 170.60	-	153.25 ± 3.61
2019-20	997.89 ± 121.56	1856.98 ± 234.56	151.25 ± 2.90

Table 166. Egg production in Kamrupa chicken

Year	Egg production (Nos)						Egg weight (g)	
	40 wks (HH)	40 wks (HD)	40 wks (Survivor)	52 wks (HH)	52 wks (HD)	52 wks (Survivor)	40 wks	52 wks
2013-14	46.96	48.34	51.24	84.90	86.34	89.21	51.93 ± 2.81	55.61 ± 3.56
2014-15	46.10	47.20	50.25	85.25	87.20	90.25	52.94 ± 2.60	56.20 ± 3.60
2015-16	46.90	48.10	50.95	87.30	89.10	91.60	53.15 ± 2.75	56.80 ± 3.40
2016-17	47.10	48.20	51.10	87.60	89.50	91.80	53.60 ± 2.85	56.95 ± 3.90
2017-18	48.30	49.50	51.60	88.90	90.30	92.60	54.20 ±2.60	56.30 ± 4.10
2018-19	49.20	50.60	52.80	90.40	92.60	93.80	56.10 ± 3.20	58.20 ± 5.40
2019-20	50.60	51.80	53.90	-	-	-		

Table 167. Growth performance of Kamrupa under field conditions

Year	BW 5, wks (g)	SL 5, wks (mm)	BW 20, wks (g)	BW 40, wks (g)
2013-14	141.3 ± 4.43	46.18 ± 2.59	764.9 ± 56.49	1565 ± 210.52
2014-15	145.2 ± 4.69	47.20 ± 3.10	810.2 ± 61.25	1510 ± 240.35
2015-16	160.2 ± 5.78	47.60 ± 2.90	895.1 ± 76.35	1580 ± 290.60
2016-17	180.3 ± 6.10	47.85 ± 2.80	910.2 ± 86.10	1595 ± 310.25
2017-18	185.4 ± 6.80	48.30 ±2.65	950.4 ± 90.20	1511 ± 290.40
2018-19	210.6 ±7.10	49.20 ± 3.60	980.3 ± 95.20	1621 ± 310.60
2019-20	215.8 ± 8.60	49.60 ± 4.30	1021 ± 150.30	-

Table 168. Conformation traits in Kamrupa under field conditions

Year	SL 5, wks (mm)	BA 5, wks (°)	KL 5, wks (mm)
2013-14	46.18 ± 2.59	51.43 ± 3.56	49.67 ± 2.21
2014-15	47.20 ± 3.10	50.65 ± 3.90	51.25 ± 3.10
2015-16	47.60 ± 2.90	51.10 ± 4.25	51.65 ± 4.25
2016-17	47.85 ± 2.80	51.60 ± 4.65	51.90 ± 5.15
2017-18	48.30 ±2.65	50.80 ±5.20	52.30 ±6.20
2018-19	49.20 ± 3.60	51.60 ± 6.30	53.60 ± 7.10
2019-20	49.60 ± 4.30	51.70 ± 7.50	53.90 ± 8.60

Table 169. Age at first egg, egg production and egg weight in Kamrupa under field conditions

Year	AFE (days)	EP 40, wks (Nos)	EP 52, wks (Nos)	EW 40, wks (g)	EW 52, wks (g)
2013-14	174.98	41.38	72.89	57.20±3.10	59.50±3.20
2014-15	175.23	42.10	72.10	56.87±2.90	58.60±2.90
2015-16	174.80	42.60	72.80	57.54±3.10	58.23±3.15
2016-17	172.90	42.85	72.90		
2017-18	171.10	43.65	73.80		
2018-19	170.40	44.80	75.20		
2019-20	172.60	42.60			

The Centre has distributed 2.97 lakhs of chicken germplasm to the farmers with a revenue of Rs. 54.24 lakhs since inception of the Centre.


Figure 26: Kamrupa flocks in farmers backyards of Assam

Publications

Afzal, A.M., Anitha, P., Leo Joseph, Sankaralingam, S. and Anil, K.S. 2016. Evaluation of egg quality traits in four crossbred birds under backyard system - A comparative study. Journal of Indian Veterinary Association, Kerala, 14(1): 48-51.

Agrawal, A., Khan, A.G., Bhardwaj, J.K. and Paradkar, N.G. (1996). Post natural moult performance of two lines of dwarf broiler breeder dams. World Poultry Congress, New Delhi, 2-5 Sept., 96: p 416.

Agrawal, A., Khan, A.G., Nema, R.P. and Bhardwaj, J.K. (1996). Clutch size and productive traits relationship in Krishna –J. World Poultry Congress, New Delhi, 2-5 Sept., IV: p32.

Agrawal, A., Nema, R.P., Chakrabarti, R.L. and Atkare, S.S. (1998). Genotype and nutrient levels interaction on Production performance of inters and corssbred dwarf under summerstress national Seminar on Tech. Adv. In Agri. And livestock Prod. in M.P. 20-22, April, JNKVV, Jabalpur p.78.

Akhatar, S., Nema R.P., Bhardwaj, J.K. and Atkare, S.S. (2009). Influence of housing and dietary protein on performance traits of pure and crossbred kadaknath birds. XXV Annual conf. and National Sympo. of IPSA, 10-12 Dec., 2008. Vety College, Anand Agri. Univ. Gujrat, pp. Abst. 194, p. 488.

Akhatar, S., Nema, R.P., Bhardwaj, J.K. and Atkare, S.S. (2009). Effect of housing and dietary protein on feed consumption and feed efficiency of pure and crossbred kadaknath birds. XXV Annual conf. and National Sympo. of IPSA, 10-12 Dec., 2008. Vety College, Anand Agri. Univ. Gujrat, pp. Abst. 178, p. 480.

Akhatar, S., Nema, R.P., Bhardwaj, J.K., Atkare, S.S. and Baghel, R.P.S. (2010). Effect of dietary protein on egg quality traits of kadaknath hens. PTE 019 p. 268.

Akhtar, S., Nema, R.P., Bhardwaj, J.K., Atkare, S.S. and Baghel, R.P.S. (2012). Effect of housing and dietary protein and feed efficiency of pure and crossbred kadaknath hen. Indian J. of Poultry Sci. 47(2): 248-250.

Akhtar, S., Nema, R.P., Bhardwaj, J.K., Atkare, S.S. and Baghel, R.P.S. (2012). Effect of housing and dietary protein on performance traits of pure and crossbred kadaknath hen. Indian J. of Poultry Sci. 47(2): 237-240.

Anees, C., Veeramani, P., Narayanankutty, K., Bency, A. and Riyas, M.A. 2010. Estimation of genetic and phenotypic parameters of economic traits in White Leghorn. Indian Journal of Poultry Science, 45(1): 14-17.

Anitha P., Jalaludeen. A and Ramakrishnan. A. 1992. Effect of housing system on protein and energy requirements of egg type layers. Journal of Veterinary and Animal Sciences, 23(1): 14-18.

Anitha, P. and Suja, C.S. 2021. Conservation of poultry genetic sources – challenges and opportunities. In: Proceedings of 13th Kerala Veterinary Science Congress 2021 held during November 13-14, 2021 at College of Veterinary and Animal Sciences, Mannuthy, Thrissur, Kerala, pp. 349-350.

Anitha, P., Jalaludeen, A. and Ramakrishnan, A. 1991. Effect of housing system on protein and energy requirements of starter chicks. Journal of Veterinary and Animal Sciences, 22(2): 31-36.

Anitha, P., Jalaludeen, A. and Ramakrishnan. A. 1991. Effect of housing system on protein and energy requirements of growing egg type pullets, Journal of Veterinary and Animal Sciences, 22(2): 47-50.

Archana, S., Sankaralingam, S., Anitha, P., Joseph, B.C. and Vasudevan, V.N. (2023). Dietary inclusion of flaxseed oil, fish oil and their combinations on production performance and egg quality traits in White Leghorn hens. Journal of Veterinary and Animal Sciences, Kerala, 54(2): 360-367.

Arsha, V.S., Chacko, B., Anitha, P., Joseph, B.C. and Sathu, T. 2019. Influence of fish oil on egg production and feed intake in Athulya and native chickens. Journal of Indian Veterinary Association, Kerala, 17(1): 49-57.

Atkare, S.S. (1988). Studies on growth rate and selection in dwarf meat line population. Third M.P. young scientist congress Feb. 28-March, 1, 1988. Gwarlior, M.P. pp. 29.

Atkare, S.S. and Khan, A.G. 1988. Relationship between part egg production records, body weight and egg weight in IWM strain of white leghorn breed. Indian Journal of Animal Science 59(3): 362-365.

Atkare, S.S. and Khan, A.G., Bhardwaj, J.K. and Paradkar, N.G. 1996. Effect of protein levels on carcass yield of commercial broiler progenies from dwarf dam x Normal sire. Indian Journal of poultry science 33(3): 329-332.

Atkare, S.S. and Khan, S. 2001. Effect of genotype, protein and energy on abdominal fat deposition of chicken. Indian Journal of Applied and pure biology 16(2): 99-102.

Atkare, S.S. and Nema, R.P. 2001. Evaluation of juvenile body weight and carcass yield of coloured birds from normal and dwarf colour dam lines. J.N.K.V.V. Research Journal 39(2) : 70-73.

Atkare, S.S. and Nema, R.P., Bhardwaj, J.K. and Paradkar N.G. 1998. Effect of anti stress treatments on performance of dwarf hens during cyclic summer heat. Indian Journal of poultry science 32(3) 226-228.

Atkare, S.S. and Paradkar, N.G. 1997. Genotype, environment and nutrient level interaction effect on performance of broiler from dwarf and normal dams. XX – Annual conference and symposium of Indian Poultry Science Association. Oct. 12-14, 2000 Tamil Nadu. Vety. and Ani. Sci. University, Tamil Nadu, PGB 04 pp. 25.

Atkare, S.S. Nema, R.P. and Paradkar, N.G. 2001. Environmental technology in poultry production system. 15th National convention on Agriculture Engineering and Seminar on sustainable development of Agri. Engineering, 29-30 Dec. 2001 pp.-62.

Atkare, S.S., Bhardwaj, J.K. and Nema, R.P. 2000. Effect of genotype, diet and climate on conformation and carcass yield of broiler chicken. XX Annual conference and symposium of Indian poultry science Association. Oct. 12-14, 2000. Tamil Nadu Vety. and Ani. Sci. University, Tamil Nadu. PGB 13 pp. 30.

Atkare, S.S., Bhardwaj, J.K. and Nema, R.P. 2004. Genotype by nutrient level interaction on growth performance of chicks from three diversified dam lines.

Atkare, S.S., Bhardwaj, J.K. and Nema, R.P. 2009. Effect of egg quality traits by feeding vit. C alone or in combination with methionine and betain. XXV Annual conference and National Symposium of IPSA 10-12 Dec., 2008. Anand Agriculture University, Gujrat, Abst. 131, p. 446.

Atkare, S.S., Bhardwaj, J.K. and Paradkar, N.G. 1996. Effect of dietary protein levels on growth and yield of commercial broilers from coloured dwarf dams. National Seminar on poultry Science. Poultry production in 2000 A.D. prospect and challenges 18-19 April. Tamil Nadu Vety and Ani. Sci. University ppm-3.

Atkare, S.S., Bhardwaj, J.K. and Paradkar, N.G. 2000. Effect of cage and floor housing system on production performance of cross bred pullets. XX Oct. 12-14, 2000. Tamil Nadu Vety. and Ani. Sci. University, Tamil Nadu. PGB 04 pp. 161.

Atkare, S.S., Bhardwaj, J.K. and Roy, P. 2001. Effect of genotype, protein and energy levels on abdominal fat yield of broiler chicks. 1st South Asian Regional Poultry Conference, 24-26. Sept. 2001. Pune India. conference proceedings. Floppy disc. page-1.

Atkare, S.S., Bhardwaj, J.K., Baghel, R.P.S. and Nigam, S. 2003. Growth and carcass characteristics of chicken as influenced by genotype diet and season. Indian J. of Poultry Sci., 38 (3): 294-298.

Atkare, S.S., Bhardwaj, J.K., Khan, S. and Nema, R.P. 2001. Growth performance of meat and dual type chicks under hot and cold climates fed variable protein and energy levels. Journal of Poultry Fortune 3(4) 22-24 (Publication of presentation in South Asian Regional Poultry Conference 2001).

Atkare, S.S., Bhardwaj, J.K., Khan, S. and Nema, R.P. 2001. Growth performance of meat and dual type chicks under hot and cold climate fed variable protein and energy levels 1st South Asian Regional Poultry Conference 24-26 Sept. 2001. Pune India. conference proceedings. Floppy disc. page-1.

Atkare, S.S., Bhardwaj, J.K., Nema, R.P. and Baghel, R.P.S. 2010. Production performance of colour dwarf hens during summer supplemented vit. C alone or in combination with methionine and betain. India J. of Anim. Prod. and Management. 26(1-2) 36-39.

Atkare, S.S., Bhardwaj, J.K., Nema, R.P. and Kadam, M.M. 2009. Production performance of dwarf hens during summer stress, fed vit. C alone or in combination with methionine and betain. XXV Annual conf. and National Sympo. of IPSA, 10-12 Dec., 2008. Vety College, Anand Agri. Univ. Gujrat, pp. Abst. 196, p. 489.

Atkare, S.S., Bhardwaj, J.K., Nema, R.P. and Paradkar, N.G. 1998. Effect of antitress treatment on performance of dwarf hens during cycle summer heat, Indian J. Poult. Sci. 33(3): 329-332.

Atkare, S.S., Bhardwaj, J.K., Nema, R.P. and Paradkar, N.G. 1998. Effect of antitress treatment on performance of dwarf hens during cycle summer heat, Indian J. Poult. Sci. 33(3): 329-332.

Atkare, S.S., Bhardwaj, J.K., Nema, R.P., Paradkar, N.G. and Chakrabarti, R.L. 1998. Heritability and genetic breeder dam population National semi. On tech Adv. in Agri. And livestock Prod. in M.P. JNKVV., Jabalpur 20-22, April, p. 78.

Atkare, S.S., Bhardwaj, J.K., Nema, R.P., Paradkar, N.G. and Chakrabarti, R.L. 1998. Heritability and genetic breeder dam population National semi. On tech Adv. in Agri. And livestock Prod. in M.P. JNKVV., Jabalpur 20-22, April, p. 78.

Atkare, S.S., Bhardwaj. J.K., Nema, R.P. Paradkar, N.G. and Chakraborti, R.L. 1998. Heritability and correlation of juvenile body weight in dwarf broiler breeder dam population. National Seminar on technology advances in Agri. & Live Stock Prod. in M.P. April 20-22. JNKVV, Jabalpur pp. 78.

Atkare, S.S., Khan, A.G. and Bhardwaj, J.K. 1996. Effect of dietary protein levels on growth and carcass yield of commercial broiler from dwarf dams. World Poultry Congress, New Delhi, India, 2-5 Sept. 96 IV: p.205.

Atkare, S.S., Khan, A.G. Bhardwj, J.K. and Paradkar, N.G. 1996. Effect of antistress treatments on production performance of dwarf egg layer during cyclic summer heat. Proceedings world poultry congress 2-5 Sept. 1996. New Delhi. India pp-265.

Atkare, S.S., Poulose, M.V. and Bhardwaj, J.K. 1996. Effects of dietary protein and cage density on performance traits of light breed pullet. National seminar on poultry science poultry production in 2000 A.D. Prospects and Challenges 18-19 April. TamilNadu Vety. and Animal Science University, ppm-2.

Azhaguraja, M., Sankaralingam, S., Anitha, P., Chacko, B., and Aravindakshan, T.V. 2017. Association of Prolactin gene polymorphism with production traits in White Leghorn. Journal of Indian Veterinary Association, Kerala, 15(2): 12-14.

Bablu Sundi, Nishant Patel, Sushil Prasad, Ravindra Kumar and Banani Mandal 2018. Carcass Characteristics of Vanaraja Birds Under Different System Of Management, Int. J. Cure. Microbio.App.Sci. special issue-7: 450-452.

Baghel, K.K.S. & Khan, A.G. 1983. Studies on Post maturity body weights of Narmada-XL dwarf pullets under variable dietary protein and energy levels. Indian, J. Anim. Sci. Vol. 53:10.

Bais, R.K.S., Khan A.G. and Atkare, S.S. 1988. Plasma uric acid and other constituents of dwarf and normal broiler progenies from heterozygous sire mated with dwarf dam. Indian Journal of Animal Science 58(2) 262-272.

Balachandran, T.N., Unni, A.K.K. and Venugopalan, C.K. 1979. A note on production characteristics of White Leghorn pullets in cages and on litter floor. Indian poultry gazette, 63(2): 83-85.

Behera, H.K., Jena, G.R., Kumar, D., Mishra, S.K., Das, D.P., Samal, L. and Dalai, N. 2020. Ameliorative effect of vitamin C on haemato-biochemical and oxidative parameters in ducks during summer. International Journal of Livestock Research, 10(11): 140-148.

Behera, S., B. Panigrahi, C.R. Pradhan,N.C. Behura, N. Pandaand J. Bagh 2017. Performance of Back Cross Progeny from Hansli Male and Coloured Broiler Female Chicken International Journal of Current Microbiology and Applied Sciences (2017); 6(7): 2739-2744

Behura, N.C. and Samal, L. 2021. Effect of climate change on sustainable backyard poultry production. In: Impact of Climate Change on livestock health and production (Eds.) Nayak, G.D., Sardar, K.K., Das, B.C. and Das, D.P., Nipa Publishing. Chapter 22. pp. 203-212.

Behura, N.C., F. Kumar, L. Samal, K. Sethy, K. Behera, G.D Nayak 2016. Use of temperature humidity index (THI) in energy modeling for broiler breeder pullets in hot and humid climatic conditions. Journal of Livestock Science 7: 75-83

Behura, N.C., Dehuri, P.K., Mishra, S.K. and Das, S.K. (2011). Feeding value of Simaruba (Simarouba glauca) fat in broilers. Indian Journal of Animal Science, 81 (10): 1060-1063.

Behura, N.C., Dehuri, P.K., Mishra, S.K. and Mohapatra, A.K. (2012). Feeding value of detoxified Simaruba (Simarouba glauca) oil cake in egg type growers. Animal Nutrition and Feed Technology, 12: 121-126.

Behura, N.C., G.D.naik, F.Kumar, P.K.Mishra and N.Barik 2013. Influence of body weight on age at sexual maturity and egg production in broiler breeder hens. Indian Vet Journal, 8: 95-96 (2013).

Behura, N.C., Mohanta, K.C., Biswal, C. et al., (2014). Effects of dietary protein intake on growth and semen quality in broiler breeder male. Animal Nutrition and Feed Technology, 14: 617-627.

Bhardwaj, J.K. and Atkare, S.S. 1996. Effect of genotype and environment interaction on broiler growth. Technical seminar and farmers symposium on poultry production. Sponsored by world poultry congress (Indian branch). February 19, 1996. Vety. College, JNKVV, Jabalpur M.P. ppm.

Bhardwaj, J.K. and Atkare, S.S. 1996. Growth and carcass yield of commercial broilers obtained from dwarf broiler dam under different feeding regime. 18th Annual conference and symposium of Indian Poultry Science Association. 11-13 Jan, 96 Truchur, Kerala.

Bhardwaj, J.K. and Dhingra, N. 2000. Genotype x environment interactions effect on broilers from dwarf and normal broiler breeder dam. JNKVV, Res. J. 31(1 & 2) : 42-47.

Bhardwaj, J.K. and Janak, A. 2001. Dependence of production traits on juvenile body weight of dwarf broiler dams. Abstr. 1st South Asian Regional Poultry Cont. (WPSA, IB) 24-26 Sept, Pune India Floppy disc.

Bhardwaj, J.K. and Pandey A. 1999. Growth and meat yield performance of commercial broiler from dwarf dams under Variable stocking density and protein level. M.P. Agri. Eco. J. Vol. 1 pp. 73-75.

Bhardwaj, J.K. and Pandey, A. 1998. Influence of genotype stocking density protein levels on growth performance of dwarf broilers dam commercial broilers National Semi. on Tech. Adv. in Agri. And livestock Prod. in M.P. JNKVV, Jabalpur 20-22, April p. 79.

Bhardwaj, J.K. and Saran, A. 2001. Influence of light protein, genotype and their interaction on carcass traits of dwarf broiler breeder dam. 1st South Asian Reginal Poultry Cont. (WPSA, IB), 24-26, Sept, Pune, India Floppy disc.

Bhardwaj, J.K. Pillai, S.K., Nema, R.P. and Atkare, S.S. 2009. Influence of genotype, energy and their interaction on growth performance of pure and crossbred kadaknath birds. XXV Annual conf. and National Sympo. of IPSA, 10-12 Dec., 2008. Vety College, Anand Agri. Univ. Gujrat, pp. Abst. 193, p. 487.

Bhardwaj, J.K., Dhingra, N. and Paradkar, N.G. 1996. Genotype x protein x energy interaction effect on mortality pattern of commercial broiler from dwarf and normal dam in cold, warm and hot climatic conditions. National seminar on P. Science Madras 18-19 April.

Bhardwaj, J.K., Dhingra, N., Khan, A.G. and Paradkar, N.G. 1996. Genotype x environment interaction effect on conformation and carcass traits of commercial broiler from dwarf and normal dam under three climatic condition. World Poultry Congress. New Delhi, India 2-5 Sept. IV: 103. Paper presented during poster session.

Bhardwaj, J.K., Nema, R.P. and Atkare, S.S. 2003. Dual purpose coloured bird A suitable germplasm for rural poultry production National symposium of Indian society of Animal production and management sustainable livestock production. A National thrust 6-8 March, 2003. pp.-61.

Bhardwaj, J.K., Nema, R.P., Atkare, S.S., Paradkar, N.G. and Nigam, S. 2003. Sex linked dwarf gene as expressed in normal bodied broiler population National symposium of ISAPM on sustainable livestock production. A National thrust 6-8 March, 2003 pp.-62.

Bhardwaj, J.K., Parihar, G.H., Nema, R.P. and Atkare, S.S. 2004. Effect of feeding dried poultry excreta, enzymes and probiotics on carcass characteristics of dwarf broiler dam commercial chicks. Paper presented in XI natonal symposium of Anim. Nutrition. (5-7 Jan, 2004).

Bhat, F.M., Atkare, S.S., Bhardwaj, J.K., Nema, R.P. and Baghel, R.P.S. 2010. Production performance of coloured normal and dwarf hen at varying temperature period of summer. PYMP – 006. p. 220.

Bhat, F.M., Atkare, S.S., Bhardwaj, J.K., Nema, R.P. and Baghel, R.P.S. 2010. Genotype, protein and vit. C level first order interaction on performance of two synthetic coloured hens in summer PNR – 0-50, p. 105.

Bhat, F.M., Atkare, S.S., Bhardwaj, J.K., Nema, R.P. and Baghel, R.P.S. 2010. Effect of genotype,protein, vit C and their interaction as performance of hen during summer period of cycle temperature. PNR 0-51; p no. 105.

Brahma, T.C. and Ramakrishnan, A. 1989. Calcium and phosphorus requirements of caged layers. Kerala Journal of Veterinary Science, 20(1): 10.

Chakrabarti, R.L., Khan, A.G., Gumosta, S.K. and Nema, R.P. 1985. Pullet viability status of purebred stains of White Leghorn breed part III, Inter strain variation for diseases. Pattern in chick and pullet mortality Indian J. Poult. Sci. 20 (3) : 207-211.

Champati, A., Samal, L., Behura, N.C., Muduli, S. and Popalghat, H.K. 2019. Growth performance of Hansli × CSML birds under intensive and semi-intensive systems of management. Journal of Entomology and Zoology Studies, 7(6): 850-853.

Champati, A., Samal, L., Behura, N.C., Muduli, S. and Popalghat, H.K. 2020. Laying performance and egg quality traits of Hansli × CSML birds under different rearing systems. Journal of Entomology and Zoology Studies, 8(4): 37-39.

Champati, A., Samal, L., Behura, N.C., Pati, P.K., Muduli, S. and Popalghat, H.K. 2020. Carcass traits and meat composition of Hansli × CSML birds under intensive and semi-intensive rearing systems. Journal of Animal Research, 10(6): 1051-1055.

Chikwa Kiran, Atkare, S.S., Bhardwaj, J.K. and Nema, R.P. 2018. Herbal response of shatarari Ashwagandha root powder and vit E. on performance of colour broilers. The pharma innovation journal 7(8): 508-510.

Chikwa Kiran, Atkare, S.S., Bhardwaj, J.K., Nema, R.P. Jitendra Kumar, Padwar, Pratibha and Vishwakarma Rashmi 2019. Transportation of broilers and issue of welfare. The pharma innovation journal, 8(1): 68-70.

Chikwa, Kiran, Atkare S.S., Bhardwaj, J.K., Nema, R.P., Jitendra Kumar, Padwar Pratibha and Vishwakarma Rashmi 2018. Effect of dietary supplementation of shatavari, Ashwagandha root powder and vit. E. on performance of colour broilers journal of entomology and zoology studies, 6(5), 153-155.

Chouhan, S.S., Jain, N. Quadri, M.A., Gehlaut, B.S., Sheikh, A.A., Mishra, A. and Bhagat, R. 2018. Effect of dietary turmeric (Curcuma longa) on serum cholesterol in Jabalpur colour layer birds. Journal of Entomology and Zoology Studies, 6(1): 1071-1074.

Churchil, R.R., John, L., Chacko, B., Praveena, P.E. and Anitha, P. 2019. Genetic Analysis of egg production and allied characters in two long term selected strains of White Leghorn, International Journal of Current Microbiology and Applied Sciences, 8(3): 1669-1678.

Churchil, R.R., John, L., Praveena, P.E. and Cyriac, S. 2019. Strain and age-related changes of semen attributes in white leghorn roosters. International Journal of Chemical Studies, 7: 1838-1842.

Churchil, R.R., Narayanankutty, K., Praveena, P.E. and Joseph, P. 2009. Influence of pre-incubation storage period on fertility, hatchability and embryonic mortality pattern of two pedigreed flocks of White Leghorn. Indian Journal of Animal Sciences, 79(3): 327-330.

Churchil, R.R., Narayanankutty, K., Praveena, P.E. and Karim, R. 2010. Influence of egg dimension characteristics on fertility and hatchability traits in White Leghorn birds. Indian Veterinary Journal, 87(1): 53-55.

Dahariya, N., Sathapathy, S., Mishra, U.K., Patra, R., Dehury, S., Joshi, S.K., Sahu, S.K. and Samal, L. 2020. Gross morphological and biometrical studies on the spleen in various chicken genotypes. Journal of Entomology and Zoology Studies, 8(5): 626-628.

Dahariya, N., Sathapathy, S., Mishra, U.K., Patra, R., Dehury, S., Joshi, S.K., Sahu, S.K., Samal, L. and Jena, B. 2023. Age related histomorphometrical studies on the major lymphoid organs of chicken. Indian Journal of Animal Research, 57 (3): 322-327. 10.18805/IJAR.B-4318

Dahariya, N., Sathapathy, S., Mishra, U.K., Patra, R., Dehury, S., Joshi, S.K., Sahu, S.K., Samal, L. and Jena, B. 2023. Age related histomorphometrical studies on the major lymphoid organs of chicken. Indian Journal of Animal Research, 57 (3): 322-327. 10.18805/IJAR.B-4318

Dahariya, N., Sathapathy, S., Mishra, U.K., Patra, R., Joshi, S.K., Sahu, S.K., Samal, L. and Jena,B. 2020. Gross morphological and biometrical studies on the bursa of Fabricius in various chicken genotypes. Journal of Entomology and Zoology Studies, 8(5): 623-625.

Dahariya, N., Sathapathy, S., Patra, R., Mishra, U.K., Sahu, S.K., Samal, L., Jena, B. and Joshi, S.K. 2020. Age wise histological studies on the major lymphoid organs in various chicken genotypes. Journal of Animal research, 10(5): 811-819.

Dahariya, N., Sathapathy, S., Patra, R., Sahu, S.K., Samal, L. and Joshi, S.K. 2020. Histo-chemical studies on the major lymphoid organs in various chicken genotypes. InternationalJournal of Livestock Research, 10 (12): 137-142.

Dar, A.A. Atkare, S.S., Bhardwaj, J.K., Nema, R.P. and Baghel, R.P.S. 2010. Crude fibre x enzyme levels interaction on performance of broiler fed SBM and SSC based diet with constant lysine and methionine level. XXVII Annual Conf. and National Symposium of IPSA, 16-18, Sept. 2010, Madras Vety. College, T.N. Vety. & Anim. Sci. Univ. Chennai, PNR. 014, p. 131.

Dar, A.A., Atkare, S.S., Bhardwaj, J.K., Nema, R.P., Baghel, R.P.S. and Qureshi. S.R. 2010. Crude fibre x enzyme levels interaction on performance of broilers fed SBM and SFC based diet with constant lysine and methionine levels. PNR 0-19, p. 88.

Dar, A.A., Atkare, S.S., Bhardwaj, J.K., Quershi, S.R., Quadri, S.A. and Shrivastava, R. 2010. Effect of choline chloride supplementation on performance of broiler. PNR 0-35, p. 96.

Dar, A.A., Atkare, S.S., Nema, R.P., Bhardwaj, J.K. and Baghel, R.P.S. 2010. Effect of feeding high fibre low energy diet with and without enzyme supplementation to broiler chicken. Indian J. of Poultry Science, 2011, 46(3) : 320-325.

Dar, A.A; Atkare, S.S; Bhardwaj, J.K; Nema, R.P. and Baghel, R.P.S. 2010. Performance of broiler at varying levels of crude fibre and enzyme mixture with constant lysme as methionine levelsin SBM and SFC based diet. PNR 0-13, P. No. 130.

Das, A., Mishra, S.K., Behura, N.C. et al., (2014). Effects of organic minerals supplementation on growth, bioavailability and immunity in layer chicks. International Journal of Pharmacology 10(5):237-247.

Das, K. K., Ahmed, K., Kalita, N., and Deka, N. 2015. "Semen Characteristics of Vanaraja and Indigenous Chicken of Assam." International Journal of Applied and Pure Science and Agriculture (IJAPSA), 01, (7), 108-110.

Das, P., Khan, A.G., Kripashanker and shrivastava, P.N. 1978. Genetic combining ability for four strains of White Leghorn breed from diversified origin. Indian J. Poult. Sci. 13 (4) 224-229.

Devavratha, S., Chacko, B., Anitha, P., Harikrishnan, S. and Ramnath, V. 2021. Egg quality and fatty acid profile of yolk in eggs from Athulya, native and IWN x native crossbred layers under backyard system. Journal of Veterinary and Animal Sciences, Kerala, 52(4): 362-366.

Dhingra, N., Bhardwaj, J.K. and Khan, A.G. 1997. Growth response in broilers from dwarf dams as affected by climatic variation. Indian J. Anim. Sci. 67(6): 531-533.

Dilip Kumar Jha, Sushil Prasad, Dinesh Mahto, S.K. Soren, M. Bachan and Mritunjay Kumar, "Disease incidence in poultry under intensive management." Indian Vet. J. Vol 89(10) 39-41 (2011)

Dilip Kumar Jha, Sushil Prasad, Nishant Patel, Kathirvelu Baskar, "Comparative evaluation of dahlem red and desi crosses chicken reared under intensive system of poultry management.", Journal of agricultural technology vol.9 (6):1405-1410, 2013

Dilip Kumar Jha, Sushil Prasad, S.K. Soren and Dinesh Mahto (2011) Performance of Vanraja birds under deep litter management system. Indian Vet. J. Vol.89(1) 75-76.

Dinesh K, Sankhyan V, Thakur D, Kumar R, Bhardwaj N and Katoch S. 2023. Effect of Genotype and Season on Fertility and Hatchability of Eggs in Dahlem Red, Native and DND Chicken under Intensive System in Himachal Pradesh. Indian Journal of Animal Sciences 93(5): 460-463.

Dinesh K, Sankhyan V, Thakur D, Suman M, Sharma A and Bhardwaj N. 2021. Mortality Pattern among Poultry Stock Reared under Intensive Management in Sub temperate Condition of Himachal Pradesh. International Journal of Livestock Research 11 (4):13-18.

Dinesh K, Sankhyan V, Thakur D, Verma N and Bhardwaj N. 2022. Effect of age on egg quality traits of Dahlem Red chicken under Intensive system of management in Himachal Pradesh. Indian Journal of Animal Sciences 92 (3):347-352

Dinesh K, Sankhyan V, Thakur Y P, Kumar R and Bhardwaj N. 2020. Phenotypic Time Trend in Performance Evaluation of Dahlem red Chicken under Intensive Management in Himachal Pradesh. Journal of Animal Research 10 (3):417-422.

Dinesh K, Sankhyan V, Thakur Y P, Kumar R and Singh G. 2018. Estimation of Phenotypic Trend in Performance Traits of Native Chicken germplasm of Himachal Pradesh. Journal of Animal Research 8 (6):1071-1074.

Dinesh K, Sankhyan V, Thakur Y P, Thakur D and Kumar R. 2021. Comparative Performance Evaluation of Dahlem Red, native and their crosses under Intensive Management in Himachal Pradesh. Indian Journal of Animal Sciences 91 (10):856-859.

Ekka, R., N.C. Behura, L. Samal, G.D.Nayak, P.K. Pati, and P.K. Mishra 2017. Evaluation of carcass characteristics and meat quality of Hansli, CSML and Hansli×CSML cross under intensive system of management Advances in Bioresearch; 8 (6): 34-42

Ekka, R., N.C.Behura, L.Samal, G.D Nayak, P.K.Pati and P.K.Mishra 2016. Growth performance and linear body measurements of Hansli, CSML and Hansli X CSML cross under intensive system of rearing. Journal of Livestock Science 7: 114-121

Gautam Vidhi, Sahni, Y.P. Goyal, G., Shrivatav, Arpita and Jain Sachin 2016. Expression profile of SREBP-2 gene on hypocholesterolemic action of Nigella sativa. International conference on recent advances in biotechnology and nanobiotechnology Int-BIONANO - 2016 from February, 10-12, 2016 p. 46.

Gautam, Vidhi, Sahni, Y.P., Bhardwaj, J.K. and Jain, S., Shrivastav, A. and Singh, T. 2016. Efficacy of organic Selenium and Vitamin E for enrichment of egg in layers. Compendium XV Annual coonvention of ISVPT on Nutritional Pharmacology & Toxicology beyond calories p 96, National dairy Research Insitute, Karnal, Haryana, 14-16 January 2016.

Gautam, Vidhi, Sahni, Y.P., Bhardwaj, J.K., Jain, S., Shrivastav, A. and Singh, T. 2016. Efficacy of dietary supplementation of Withania somnifera, Selenium and Vitamin E on egg lipid profile. Compendium XV Annual connvention of ISVPT on Nutritional Pharmacology & Toxicology beyond calories p 95, National dairy Research Institute, Karnal, Haryana, 14-16 January 2016.

Gautam, Vidhi, Sahni, Y.P., Sharma, R.K. Jain, Sachin Kumar, Shrivastav, Arpita and Shriman, K. 2015. Efficacy of dietary supplementation of Nigella sativa, Selenium and Vitamin E on egg lipid profile. Journal of Veterinary Pharmacology and Toxicology, 14(1) : 36-38.

Geo, A.G., Viswanath, A. and Ramakrishnan, A. 1992. Effect of floor density on production performance of hybrid layers. Journal of Veterinary and Animal Sciences, 23(2): 18-23.

Geo, A.G., Viswanath, A. Peethambaran, P.A. and Viswanathan, T.V. 1992. Egg quality parameters as influenced by different bird density. Journal of Veterinary and Animal Sciences, 23(2): 14-17.

Giri, A.K., Bhardwaj, J.K. and Soren, S.M. 2011. Effect of housing system and dietary protein levels on conformation traits, feed efficiency and mortality of dual-purpose coloured birds. Indian Jr. of Poultry Sci., 46(1): 107-110.

Giri, A.K., Bhardwaj, J.K., Nema, R.P. and Atkare, S.S. 2005. Effect of housing system and nutrient regimes on carcass characteristics of dual-purpose coloured bird. Proceedings XXVIII PISA Con. 2-4 Feb., Hyderabad, Abst. pp. 252.

Giriraj, K., Narayanankutty, K. and Veeramani, P. 2008. Evaluation of reciprocal White Leghorn strain crosses for egg quality traits in deep litter system. Indian Journal of Poultry Science, 43(2): 241-242.

Giriraj, K., Narayanankutty, K. and Veeramani, P. 2008. Production performance of reciprocal crosses of two White Leghorn strains. Indian Journal of Poultry Science, 43(2): 239-240.

Gitte, D.S. and Khan, A.G. 1981. Genetic and environmental factors affecting serum and egg yolk cholesterol level in chicken. Ind. Poultry Review Vol. SII. 10: 15 -27.

Gitte, S.L., and Khan, A.G. 1980. Studies on cholesterol content of Narmada-XL dwarf layer.

Goyal Girraj, Upmanyu, V. Bharja, S.K. Sahni Y.P. Bhardwaj, J.K. Nema, R.P. and Sharma, D. 2013. Molecular characteristics of different cytokines in guinea fowl. (Proceeding of xxx conf. and national symposium of IPSA 22-23 Nov. CARI Izatnagar, Abstr.) pp. 11: 141-142.

Goyal, G., Upmayu, V., Bhanja, S.K., Sahni, Y.P., Bhardwaj, J.K., Nema R.P., Atkare, S.S., Prakash A.and Sharma D. 2014. Apotosis analysis in spleenocyte culture of guinea fowl in response to salmonelila enteritidis infection.

Greeshma, G., Sankaralingam, S., Leo Joseph, Anitha, P. and Aravindakshan, T.V. 2016. Association of SNP in the exon 2 of Ovocalyxin-32 gene with production traits in IWN strain of White Leghorn. Journal of Indian Veterinary Association, Kerala, 14(2): 32-34.

Gumasta, S.K., Khan, A.G., Chakrabarti, R.L., Poulose, M.V. and Dutta, O.P. 1984. Pullet viability status of purebred strains of White Leghorn breed part I, Influence of hatch and year on interaction variations in pullet mortality. Indian J. Poult. Sci. 19 (3) : 160-164.

Gupta, R.D., Joshi, S.K., Atkare, S.S. and Baghel, K.K.S. 1989. Influence of divergent egg weight on performance of progenies form receprocal crosses of dwarf x normal population. Indian J. of Animal Science, 58(1): 130-132.

Harikrishnan, S., Chacko, B., Anitha, P., Joseph, B.C., Anilkumar, K. and Mathew, J. 2019. Performance of the production characteristics of the reciprocal crosses of native chicken of Kerala and N Strain (IWN) of White Leghorn. International Journal of Current Microbiology and Applied Sciences, 8(12): 1562-1567.

Harikrishnan, S., Chacko, B., Anitha, P., Joseph, B.C., Anilkumar, K. and Mathew, J. 2019. Phenotypic characterization of native chicken of Kerala reared under intensive system of management. Indian Journal of Pure & Applied Biosciences, 7(6): 402-407.

Jain, A.G. and Khan, A.G. 1981. Effect of dam on body weight of dwarf and normal pullets. Indian J. Poultry Sci. Sys. Trichur B 28: 18.

Jain, A.G., and Khan, A.G. 1980. Effect of genotype of dam on body weight of dwarf and normal pullets. Indian J. Poultry Sci.. B 28: 18

Jalaludeen, A. and Ramakrishnan, A. 1989. Dietary protein and energy requirements of caged layers. Indian Journal of Poultry Science, 24(2).

Jalaludeen, A. and Ramakrishnan, A. 1989. Protein and energy requirements of caged layers. Kerala Journal of Veterinary Science, 20(2): 33-37.

Jalaludeen, A. and Ramakrishnan, A. 1989. Studies on the effect of limited watering time on the moisture content of droppings in caged layers. Indian Journal of Poultry Science, 24(2):

Jalaludeen, A. and Ramakrishnan, A. 1993. Protein and energy requirements of growing egg type pullets during winter. Journal of Veterinary and Animal Sciences, 24: 95-99.

Jalaludeen, A. Peethambaran, P.A., Lalithakunjamma, C.R., Laly John, C. and Unni, A.K.K. 1989. Pattern of mortality in two strains of White Leghorn. Kerala Journal of Veterinary Science, 20(1): 50-53.

Jalaludeen, A. Ramakrishnan, A. and Unni, A.K.K. 1980. Studies on the effect of limited watering time on the moisture content of droppings in caged layers. Indian Journal of Poultry Science, 13(3): 134-138.

Jalaludeen, A. Ramakrishnan, A. and Venugopalan C.K. 1979. Effect of restriction of water on certain production characteristics of caged layers. Indian Veterinary Journal, 56: 839-843.

Jalaludeen, A. Unni, A.K.K., Andrews, C.V. and Leo Joseph. 1980. Influence of season on fertility and hatchability of chicken eggs. Kerala Journal of Veterinary Science, 11(1): 115-118.

Jalaludeen, A., Ramakrishnan, A., Unni, A.K.K. and Venugopalan, C.K. 1990. Internal egg quality variations as influenced by dietary protein and energy. Journal of Veterinary and Animal Sciences, 21(2): 9-14.

Janak, A., Bhardwaj, J.K. and Atkare, S.S. 2001. Genetic and non genetic variation among juvenile and adult body weight of dwarf broiler breeder dam lines. 1st South Asian Regional Poultry conference. 24-26 Sept. 2001. Pune, India Conference proceedings Floppy disc. page 1.

Janoria, R.B.S., Nema, R.P., Bhardwaj, J.K., Atkare, S.S. and Baghel, R.P.S. 2010. Genotype x protein x supplementation of methionine x lysine effect of growth performance, confirmation and carcass traits of purebred and crossbred kadaknath. PNR 034, p. 141.

Janoria, R.B.S.; Nema, R.P; Bhardwaj, J.K; Atkare, S.S. and Baghel, R.P.S. 2010. Effect of protein level and supplimentation of methionine and lysineon growth of purebred and cross bred Kadaknath. PNR – 063, P. No. 111.

Jarada, P, Mishra, S and Rajkumar U*. 2021. Evaluation of Mewari, a native chicken breed vis a vis Pratapdhan, an improved chicken variety under intensive system of rearing. Indian Journal of Animal Sciences, 91(12). 1061-1067.

Jareda, P., Mishra, S., Chaudhary. J.L., Singh, H. & Upadhyay, B. 2019. Comparative evaluation of hatchability performance of Mewari and Pratapdhan chicken under intensive system of rearing. Indian Journal of Extension Education and Rural Development, 27: 190-192

Jena, B.P., Panda, N., Patra, R.C., Mishra, P.K., Behura, N.C. and Panigrahi, B 2013 Supplementation of vitamin E and C reduces oxidative stress in broiler breeder hens during summer. Food and Nutrition Science.

Joshi, A.G., Soni, J.L. & Khan, A.G. 1979. Sprirochaetosis anaemia and its influence on

Kalita, N., Ahmed, M., and Pathak, N. 2015. "Performance of Dahlem Red bird in intensive system of management." The Indian Veterinary Journal, 92(12), 36-38.

Kalita, N., Ahmed, M., and Pathak, N. 2015. "Performance of Vanaraja Bird in Rural condition of Assam." Indian Veterinary Journal, 92(5), 90-91.

Kalita, N., Ahmed, M., and Pathak, N. 2018. "Comparative study on physical characteristics of semen of PB2X Indigenous and Dahlem Red chicken." International Journal of Chemical Studies, 2018:6(1), 1296-1298.

Kalita, N., Barua, N., Baruah, G., Pathak, N., and Islam, R. 2010. Incidence of Newcastle disease in an indigenous flock of chicken in Assam. In XXVII Annual Conference of IAVP (Abstract No. IPD 30). November 25-27, 2010. AAU, Khanapara, Guwahati-22, Assam.

Kalita, N., Barua, N., Chutia, H., Islam, R., Pathak, N., and Kalita, R. 2011. "Egg quality and carcass characteristics of Vanaraja and Indigenous chicken reared under intensive system." Indian Veterinary Journal, 88(10), 66-68.

Kalita, N., Barua, N., Islam, R., and Kalita, R. 2011. "Livelihood promotion through indigenous chicken farming in Assam." Presented as an abstract in the 9th Asia Pacific Poultry Conference held at Taipei, Taiwan, March 20-23, 2011. Also presented in oral sessions.

Kalita, N., Barua, N., Pathak, N., and Islam, R. 2011. "Etiopathology of dead–in–shell embryos of Indigenous chicken egg." Indian Journal of Poultry Science, 46(2), 275-277.

Kalita, N., Barua, N., Pathak, N., and Islam, R. 2012. "Performance of Vanaraja birds reared under intensive system of management in Assam." Indian Journal of Poultry Science, 47(1), 125-127; Short Communication.

Kalita, N., Barua, N., Sarmah, S., Islam, R., and Pathak, N. 2011. "Blood Chemical Profile in Indigenous Chicken of Assam." Indian Veterinary Journal, 88(12), 59-61.

Kalita, N., Islam, R., Pathak, N., and Chutia, H. 2012. "Effect of season on fertility, hatchability and embryonic mortality of eggs in an indigenous flock of Assam." Indian Veterinary Journal, 89(6), June 2012, 101-102.

Kalita, N., Islam, R., Pathak, N., and Chutia, H. 2012. "Hatchability and mortality of indigenous chicken in Assam." Indian Veterinary Journal, 89(5), May 2012, 35-36.

Kalita, N., Pathak, N., Ahmed, M., and Deka, P. 2016. "Gangrenous dermatitis in a flock of Dahlem Red bird." The Proceedings of XXXIII IPSACON 2016, Abstract No OP-VII.13, 297.

Kalita, N., Pathak, N., Ahmed, M., and Talukdar, J. K. 2012. "Evaluation of crossbred (Pb2X Indigenous) chicken under intensive and backyard system of rearing." In XXIX Annual Conference and national symposium of Indian Poultry Science Association (IPSACON-2012), 5-7 December 2012, PDP, Hyderabad. Abstract no 331, Souvenir.

Kalita, N., Pathak, N., Ahmed, M., Deka, P., and Barkataki, B. 2017. "Various causes related to Dead-in–shell embryos of Kamrupa and Dahlem Red birds' egg." Journal of Entomology and Zoology Studies, 2017:5(6), 153-155.

Kalita, N., Pathak, N., Ahmed, M., Saikia, G. K., and Kalita, K. P. 2012. "Various causes related to dead in shell embryos of Vanaraja and Crossbred chicken egg." In XXIX Annual Conference and national symposium of Indian Poultry Science Association (IPSACON-2012), 5-7 December 2012, PDP, Hyderabad. Abstract no 350, Souvenir.

Kalita, N., Pathak, N., and Ahmed, M. (2014). "Blood biochemical profile of Vanaraja, Dahlem Red, PB-2, PB-2XIndigenous, and PB-2XIndigenousXDahlem Red birds under intensive system of Management." Indian Journal of Poultry Science, 49(2), 217-219.

Kalita, N., Pathak, N., and Ahmed, M. 2012. "Studies on the various traits of Vanaraja bird in intensive system of Management." Indian Journal of Animal Production and Management, 28(1-2), 128-130.

Kalita, N., Pathak, N., and Ahmed, M. 2014. "Evaluation of a three-way cross of PB-2, Indigenous and Dahlem Red Chicken under extensive system of Management." Indian Journal of Poultry Science, 49(2), 215-216.

Kalita, N., Pathak, N., and Ahmed, M. 2014. "Evaluation of crossbred (PB-2XIndigenousXDahlem Red) Chicken under Intensive System of rearing." Indian Veterinary Journal, 91(9), 9-10.

Kalita, N., Pathak, N., and Ahmed, M. 2014. "Various traits of PB-2 bird in intensive system of Management." Indian Journal of Animal Production and Management, 30(3-4), 126-127.

Kalita, N., Pathak, N., and Ahmed, M. 2015. "Studies on the various traits of Indigenous chicken in intensive system of Management." The North–East Veterinarian, XV (2) 10-12.

Kalita, N., Pathak, N., and Ahmed, M. 2016. ""Kamrupa"-A new dual chicken variety for farmers of Assam and North-East India." Indian Journal of Animal Science, 86(6), 686-690

Kalita, N., Pathak, N., and Ahmed, M. 2016. "Comparative evaluation of Kamrupa, Vanaraja, PB2XIndigenous, and Indigenous chicken in rural conditions of Assam and North-East India." The Proceedings of XXV Worlds Poultry Congress 2016, Abstract no S-14-0014, 5-9 September 2016, 633.

Kalita, N., Pathak, N., and Ahmed, M. 2016. "Comparative evaluation of Indigenous and Kamrupa bird in extensive system of management in rural conditions of Assam." The Proceedings of XXXIII IPSACON 2016, Abstract No OP-I.15, 45.

Kalita, N., Pathak, N., and Ahmed, M. 2016. "Evaluation of crossbred (PB-2XIndigenous) chicken under intensive and backyard system of rearing." The North–East Veterinarian, XVI (3), 28-29.

Kalita, N., Pathak, N., and Ahmed, M. 2016. "Kamrupa, a dual-type new variety of chicken for rural poultry production in Assam and North-East India." The Proceedings of XXV Worlds Poultry Congress 2016, Abstract no S-16-0010, 5-9 September 2016, 655.

Kalita, N., Pathak, N., and Ahmed, M. 2016. "Outbreak of various diseases in different flocks of AICRP on Poultry Breeding." The North–East Veterinarian, XVI, (I) 16-17.

Kalita, N., Pathak, N., and Ahmed, M. 2016. "Studies on Annual egg production of Indigenous, Vanaraja, and PB2XIndigenous chicken in both extensive and intensive system of rearing." The North–East Veterinarian, XV, (4), 6-7.

Kalita, N., Pathak, N., and Ahmed, M. 2017. "Comparative evaluation of various traits of PB-2X Indigenous and Dahlem red chicken under intensive system of rearing." Journal of Entomology and Zoology Studies, 5(6), 155-159.

Kalita, N., Pathak, N., and Ahmed, M. 2017. "Studies on different traits of PB-2X Indigenous crossbred chicken under extensive system of rearing." The North-East Veterinarian, XVI (4), 7-8.

Kalita, N., Pathak, N., and Islam, R. 2012. "Gangrenous dermatitis in a flock of Vanaraja Chicken." Indian Journal of Poultry Science, 47(1), 112-113; Short Communication.

Kalita, N., Pathak, N., and Islam, R. 2012. "Indigenous chicken and its contribution in livelihood security of rural farmers in Assam." Journal of Extension Education, 24(4), 4953-4956

Kalita, N., Pathak, N., and Islam, R. 2012. "Performance of indigenous chicken in intensive system of management." Indian Veterinary Journal, 89(12), 43-44.

Kalita, N., Pathak, N., and Islam, R. 2012. "Performance of PB-2 Bird under intensive system of management." Indian Veterinary Journal, 89(12), 102.

Kalita, N., Pathak, N., Islam, R., and Chutia, H. 2010. Mortality pattern in a flock of indigenous chicken reared under intensive system of management. In XXVII Annual Conference of IAVP (Abstract No. IPD 29). November 25-27, 2010. AAU, Khanapara, Guwahati-22, Assam.

Kalita, N., Pathak, N., Islam, R., and Chutia, H. 2011. "Production traits of Indigenous chicken in rural condition of Assam." Indian Journal of Poultry Science, 46(2), 245-246.

Kalita, N., Pathak, N., Islam, R., and Mukit, A. 2010. Incidence of Gangrenous dermatitis in a flock of Vanaraja Bird. In XXVII Annual Conference of IAVP (Abstract No. IPD 28). November 25-27, 2010. AAU, Khanapara, Guwahati-22, Assam.

Kalita, N., Pathak, S. S., Pathak, N., Ahmed, M., and Sheikh, I. U. 2017. "Comparative evaluation of carcass characteristics of PB-2xIndigenous and Dahlem Red chicken." The North-East Veterinarian, XVII (2), 18-19.

Kalita, N., Pathak, S., Pathak, N., Ahmed, M., and Seikh, I. U. 2015. "Comparative evaluation of fertility and hatchability of PB2XIndigenous and Indigenous chicken." The North–East Veterinarian, XV, (3), 34-35.

Kalita, N., Sheikh, I. U., Pathak, N., and Ahmed, M. 2016. "Economics of rearing Indigenous, Vanaraja, PB2xIndigenous, and Dahlem Red birds under Intensive system of Management." Indian Veterinary Journal, 93(04), 26-29.

Kaur N, Bajwa IS, Singh B and Trehan PK 2007. Comparative evaluation of support and demand tissues of two genetically disparate broiler stocks. Indian Journal of Poultry Science 42(3): 306-310.

Kaur T, Ravi Kumar GVPPS, Bajwa IS and Trehan PK 2008. PCR-RFLP of Growth Hormone gene in Meat-type chicken. Indian Journal of Poultry Science 43(2):129-133.

Kaur T, Trehan PK, Singh B and Bajwa IS 2006. Estimates of genetic parameters for three prime cut-up parts in broilers. Indian Journal of Poultry Science 41(3): 289-293.

Khan, A.G. & Rath, M. 1979. Genetic studies on body weight of normal and dwarf siblings form

Khan, A.G. 1974. Dwarfism A new concept in egg layers. Poultry Guide, 1974.

Khan, A.G. 1979. Utilization of sex linked dwarfism in economics of Poultry Production. Indian. Poultry. Poultry. Review. 10: (13) 21-29.

Khan, A.G. and Baghel, K.K.S. 1982. Studies on egg production and egg weight of dwarf pullets under variable dietary protein and energy levels. (Submitted) Indian J. Anim. Sci. 5-4-82.

Khan, A.G. and Baghel, K.K.S. 1983. Egg production and egg weight of dwarf pullets under variable dietary protein and energy levels. Indian J. Anim. Sci. 53(11): 1252-1257.

Khan, A.G. and Baghel, K.K.S. 1983. Feed efficiency of 'Narmada – XL' dwarf pullets under laying period. Indian J. Anim. Sci. 53(9): 1044-1046.

Khan, A.G. and Gupta, R.D. 1979. Genotype environment interaction in protein utilization for the progeny form reciprocal mating of the dw-arf and normal parents. Ind. Poultry Sci. Sym. Hissar N 1:8

Khan, A.G. and Lad, B.K. 1996. Consequences of induced rest feeding programme (IRFP) on dwarf layer. Indian J. of Anim. Science. 66(2) 177-183.

Khan, A.G. and Prasad, J.R. 1981. Inculation mortality of developing chick embryos having diversified genetic origin. Indian J. of Poult. Sci. 10, 280-282.

Khan, A.G. and Rath, M. 1979. Influence of Dw gene on crude fibre utilization in chicken. Indian Poultry Sci. Asso. Symp. Hissar N 83:51

Khan, A.G. and Rath, M. 1980. Quality deterioration of preserved eggs. Poultry Advisor. 13: 7 : 77 – 17.

Khan, A.G. and Shyamkali Patel 1996. Interactions of plumage Chromatism with diets containing probiotice and enzymes on economic traits in dwarf laying hens. Indian J. of Anim. Science 66(7) : 718-723.

Khan, A.G. and Verma, A.K. 1982. Influence of dw gene on egg production of Narmada-XL egg layer and dwarf and normal broiler pullet. Indian J. Anim. Sci. 23-2-82.

Khan, A.G. and Verma, A.K. 1983. Influence of dw gene on egg production of 'Narmada – XL' egg layer and dwarf normal broiler pullets. Indian J. Anim. Sci. 53(9) : 978-984.

Khan, A.G. Jain, A.K. and Rath, M. 1983. Effect of feed restriction on productive traits of dwarf and normal siblings of white Leghorn breed. Indian J. Anim. Sci. 53 (3): 297-300.

Khan, A.G., & Jain, A.K. 1981. Traits of economic importance and dwarfism in egg layer. Ind. Poultry. Gaztte 64 (3) 88-96.

Khan, A.G., 1980. Narmada – XL A Mini egg layer poultry advisor 13: 7: 2 -26.

Khan, A.G., 1980. Narmada – XL, Poultry Review: 10 No. 20 (2)25.

Khan, A.G., Ali, M.A. and Rath, M. 1980. Genetic studies on body weight of dwarf and normal chicks hatched from normal White Leghorn. 6th European Poultry conference 8 -12, Sept. 80, Hamburg, Vol. II: 256 – 262

Khan, A.G., and Baghel, K.K.S. 1983. Egg production and egg weight of dwarf pullets under variable dietary protein and energy levels. Indian J. Anim. Sci. 53 (11): 1252-1257.

Khan, A.G., and Baghel, K.K.S. 1983. Feed efficiency of Narmada-XL dwarf pullets under laying period. Indian J. Anim. Sci. 53 (9): 1944-46.

Khan, A.G., and Jairam Prasad 1981. Incubation mortality of developing chick embryos having diversified genetic origin Ind. J. Poultry Sci. 16 : 280 – 282.

Khan, A.G., AND Sing, A.B. 1979. Genetic improvement in body weight and egg weight in Turkey. Poultry Review Vol. X. No. 13: 1979.

Khan, A.G., and Verma, A.K. 1983. Influence of dw gene on egg production of 'Narmada-XL' egg layer and dwarf and normal broiler pullets. Indian J. Anim. Sci. 53(9) 978-984.

Khan, A.G., Das, P. and Shrivastava, P.N. 1978. Sire and dam effect on egg quality parameters. Ind. J. Poult. Sci. 13(4) 195-197.

Khan, A.G., Gumasta, S.K., Srivastava, P.N. and Dutta, O.P. 1985. Pullet viability status of pure bred strains of White Leghorn breed. Part II: Genetic variance of pullet viability. Indian J. Poult. Sci. 20(2): 106-111.

Khan, A.G., Gupta, R.D. and Singh, S.K. 1981. Influence of dietary protein level on body weight gain of progeny from reciprocal crossing of dwarf and normal parent Ind. Anim. Sci. 51: 7.

Khan, A.G., Jaap. R.G. and Hervey, W.R. 1973. The effect and egg weight on eight weeks body weight of normal and dwarf progeny from dwarf dams. Poultry Sci. 52:211-218.

Khan, A.G., Jain A.K. and Rath, M. 1980. Studies on feed restriction responses in dwarf and normal sibling. Ind. J. Poultry Sci. B 27 – 17.

Khan, A.G., Khanna, K. and Ali, M.A. 1983. Consequences of increasing broiler inheritance on juvenile body weights of dwarf and normal pullets. Indian J. Anim. Sci. 53 (11) : 1257-1260.

Khan, A.G., Prabhu, G.A., Datta, I.C. and Ali, M.A. 1983. Genetic influence of sire and dam on transfer of inorganic ions in pure-bred and cross-bred embryos. Indian J. Anim. Sci. 53(3): 291-296.

Khan, A.G., Rath. M. and Singh, S.K. 1979. Studies on amino acid utilization by dwarf and normal pullets form normal dam. Ind. J. Poultry Sci. Sym. Hissar.

Khan, A.G., Tiwari, R.N.S., Baghel, K.K.S. and Verma, A.K. 1984. Influence of body weight on egg production of dwarf pullets. Ind. J. Anim. Sci. 55:7:

Khan, A.G., Tiwari, R.N.S., Baghel, K.K.S. and Verma, A.K. 1985. Influence of body weight on egg production of dwarf pullets. Indian J. Anim. Sci. 55(7) : 606-607.

Khanna, K. and Khan, A.G., 1980. Effect of successive back crossing on growth rate of dwarf broiler pullets B – 29: 18.

Kumar, A.S., Leo, J., Peethambaran, P.A. and Unni, A.K.K. 2001. Effect of pullet body weight on age at sexual maturity, mature body weight and egg quality. Journal of Veterinary and Animal Sciences, 32: 36-41.

Kumar, A.S., Leo, J., Peethambaran, P.A. and Unni, A.K.K. 2002. The influence of pullet body weight on egg number and egg weight. Journal of Veterinary and Animal Sciences, 33: 35-40.

Kumar, D., Vaish, R., Bhardwaj, J.K., Pandey, Yogita and Rajput, Nidhi 2017. Comparative studies on ovary of kadaknath and white leghorn fowl. National symposium on advances and applications of veterinary anatomy in livestock, pet, poultry, lab animals and wild life health production 21-23 December, 2017.

Kumar, D., Waish, Rakhi, Bhardwaj, J.K., Pandey, Yogita, Gupa, Nidhi and Rajput, Nidhi 2017. Gross structure and biometry of every in kadaknath and white leghorn breed of fowl. Indian J. Vet. Science and Biotechnology, 12(4): 34-37.

Kumar, K., Bhardwaj, J.K., Nema, R.P. Atkare, S.S., Baghel, R.P.S. and Sikrodia, R. 2017. Effect of hosing system and protein levels on egg production performance of commercial colour birds. Life Science Bulletin in 14(1): 117-119.

Kumar, K., Bhardwaj, J.K., Nema, R.P., Atkare, S.S., Baghel, R.P.S. and Sikrodia, R. 2017. Effect of housing system and feed consumption of commercial colour birds. Life Science Bulletin. 14(1): 120-122.

Kumar, V.P., and Khan, A.G. 1978. Inhoritance of body weight in white Rock and White Cornish broiler breeds of fowl. Ann. Sym. Indian Poult. Sci. Asso. P. 35.

Laly John C, Jalaludeen. A and Anitha P. 2000. Impact of selection for part period egg production in two strains of White Leghorn. Indian Journal of Poultry Science, 35(2): 156-160.

Mahadik, P.S., Khan, A.G. and Bhardwaj, J.K. 1996. Growth response to dietary energy and protein variation for commercial broiler from dwarf dams. World P. Congress New Delhi, 2-5 Sept, IV: 134-135.

Majhi, M., Pamia, J., Panda, S.K. and Samal, L. 2019. Pathological studies of enteritis in chickens of Odisha. Journal of Entomology and Zoology Studies, 7(6): 1230-1235.

Majhi, M., Pamia, J., Panda, S.K., Samal, L. and Mishra, R. 2018. Effect of age and season on enteritis and antibiotic sensitivity test of E. coli isolated from infected chickens in Odisha, India. International Journal of Current Microbiology and Applied Sciences, 7(3): 2037-2045. doi: https://doi.org/10.20546/ijcmas.2018.703.239

Mangle, V.S., Dutta, I.C. AND Khan, A.G. 1979. association of certains bio-chemical constituents of blood with production traints in white leghorns. Indian J. Ani. Sci. Nov. 1979.

Manoharan, A. and Sankaralingam, S. 2021. Identification of single nucleotide polymorphism (SNP) C-2161G in the promoter region of Prolactin gene and its association with egg production in Tellicherry native chicken. Indian Journal of Animal Research, 10.18805/ IJAR.B-4370, pp.1-4.

Manoharan, A., Sankaralingam, S. and Anitha, P. 2021. Characterization of 24bp insertion polymorphism of Prolactin gene and its association with quantitative traits in Tellicherry native chicken breed. Indian Journal of Animal Research, 10.18805/ IJAR.B-4479, pp.1-5.

Manoharan, A., Sankaralingam, S., Anitha, P., Chacko, B. and Aravindakshan, T.V. 2020. Genotypic confirmation of non-broody behaviour of white leghorn by 24bp indel(s) polymorphism at the promoter region of prolactin gene. International Journal of Chemical Studies, 8(2): 2491-2493.

Manoharan, A., Sankaralingam, S., Anitha, P., Chacko, B. and Aravindakshan, T.V. 2020. Single nucleotide polymorphism C-2161 in promoter region of prolactin gene in 'N' strain of White Leghorn. International Journal of Current Microbiology and Applied Sciences, 9(4): 1996-1999.

Manoharan, A., Sankaralingam, S., Anitha, P., Chacko, B. and Aravindakshan, T.V. 2020. Identification of single nucleotide polymorphism (SNP) in prolactin gene in white leghorn and its association with production traits. Journal of Entomology and Zoology Studies, 8(2): 1615-1617.

Manoharan, A., Sankaralingam, S., Anitha, P., Chacko, B. and Aravindakshan, T.V. 2021. Identification of 24bp indel (s) polymorphism in the promoter region of prolactin gene and its association with broodiness in Tellicherry native chicken. Indian Journal of Animal Research, 55(10):1137-1140.

Manoharan, A., Sankaralingam, S., Anitha, P., Chacko, B. and Aravindakshan, T.V. 2022. PCR-RFLP Analysis of single nucleotide polymorphism (SNP) C-2402T at the promoter region of Prolactin gene and its association with positively correlated production traits in White Leghorn chicken. Indian Journal of Animal Research, 56(8): 917-920.

Mathew, M.L., Venugopalan, C.K. and Ramakrishnan, A. 1980. Economics of raising White Leghorn male chicks for meat. Kerala Journal of Veterinary Science, 11.

Maya, S., Anitha, P., Aravindakshan, T.V., Sunanda, C., Indu, V.R., Sreeranjini, A.R., Sunilkumar, N.S. and Sumena, K.B. 2020. Study of the anomalies in unhatched chicken eggs. Journal of Veterinary and Animal Sciences, Kerala, 51(1): 70-74.

Mishra, R. K., Savaliya, F. P., Rank, D. N., Vataliya, P. H., Solanki, J. V., Patel, M. M., Shukla, R. K., Joshi, R. S., Paleja, H. I. and Kuldeep Khanna. (2001). Genetic studies of part period egg production in two strains of White Leghorn under reciprocal recurrent selection. Presented at South Asian Regional Poultry Conference, 24-26 September held in Pune, India.

Mishra, R. K., Savaliya, F. P., Rank, D. N., Vataliya, P. H., Solanki, J. V., Patel, M. M., Shukla, R. K., Joshi, R. S., Paleja, H. I. and Khanna, K. 2003. Genetic study on part period egg production in two strains of white leghorn under reciprocal recurrent selection. Poultry Fortune, 5(1):33–34

Mishra, S, RN Chatterjee, S Haunshi, U Rajkumar. 2022. Characterization of Mewari, an indigenous chicken breed, from hot tropical climate of India. Indian Journal of Animal Sciences 92 (12), 1408-14

Mishra, S., Dash S.K., Samal, L., Mallick, B.K., Karna, D.K., Mishra, P.C., Mishra, C. and Kundu, A.K. (2023). Phenotypic characterization and body conformation traits of native Vezaguda, Phulbani and Hansli chickens of Odisha. The Pharma Innovation, 12 (1): 1001-1004.

Mishra, S., Majumder, S., Dash S.K., Samal, L., Mallick, B.K., Karna, D.K., Mishra, C. and Kundu, A.K. (2023). Growth and production potentials of Vezaguda chicken in its home tract. The Pharma Innovation, 12 (5): 1681-1683.

Mishra, S., Tailor, S.P., Gupta, L., Bugaliya, H.L. and Dangi, B.L. 2019. Characterisitics of local chicken birds from Southern Rajasthan region. International Journal of Livestock Research. 9(5): 120-127.

Mishra, S.K., R.K.Swain, N.C.Behura, A.Das, A.Mishra, G.Sahu and A.K.Das 2013. Indian J. Animal Science, 83(2):Effect of supplementation of organic minerals on the performance of broiler. 1335-1339.

Mohanta, N.B., Samal, L., Behura, N.C., Pati, P.K., Bagh, J. and Nandi, B. 2018. Egg quality traits and meat composition of indigenous dwarf chicken of Odisha. Journal of Entomology and Zoology Studies, 6(2): 549-555.

Mohanta, N.B., Samal, L., Behura, N.C., Pati, P.K., Maity, A. and Bagh, J. 2022. Growth performance, feed utilization efficiency and blood biochemical parameters of Nusuri chicken population of Odisha in floor rearing system. The Indian Journal of Animal Sciences, 92(8), 1006–1012. https://doi.org/10.56093/ijans.v92i8.102495

Mohapatra, L.M., Khan, A.G., Shrivastava, P.N. and Bhardwaj, J.K. 1986. Genetic and non genetic sources of variation of fertility and hatchability. Indian J. of Anim. Sci. 56(3): 369-370.

Mohapatra, P., Swain, R.K. and Behura, N.C. et al. (2014). Effects of dietary nano selenium on tissue selenium deposition, antioxidant status and immune functions in chicks. International Journal of Pharmacology 10(3):160-167.

Mohapatra, P., Swain, R.K. and Behura, N.C. et al. (2014). Effects of dietary nano-selenium supplementation on the performance on layer-grower birds. Asian journal of Animal and veterinary Advances 9(10):641-652.

Muduli, S., Behura, N.C., Samal, L., Bagh, J., Champati, A. and Popalghat, H.K. 2019. Juvenile growth, efficiency and phenotypic correlation of body weight and growth traits of native Nusuri × broiler crosses under intensive management system. The Pharma Innovation Journal, 8(11): 258-263.

Mukherjee, B.P., Khan, F.H. and Khan, A.G. 1975. Influence of temperature on body temperature of imported strains of White leghorn cocks. Indian J. Poult. Sci. 1 C: (3) 136-14.

Naik S, Dash SK, Dubey PP, Arora J S, Sahoo SK, Kaur S, Malhotra P and Bansal BK (2019). AIREML estimation of genetic parameters and study of factors affecting growth and fertility performance of sire line of IBL-80 broiler chicken. Indian Journal of Animal Research 53(10): 1281-1286.

Naik, S.K., N.C. Behura, L. Samal, P.K. Mishra, R.K. Swain, and G.D. Nayak 2017. Effects of cumulative protein intake on growth performance and body conformation traits in female broiler breeders under intensive system of rearing International Journal of Livestock Research (2017); 7 (9): 228-236

Naik, S.K., N.C. Behura, L. Samal, P.K. Mishra, R.K. Swain, and G.D. Nayak 2017. Effects of cumulative protein intake on egg production, egg quality traits, fertility and hatchability of female broiler breeders Advances in Bioresearch (2017); 8 (6): 107-117

Nair, G.R., Unni, A.K.K. and Choudary, M.R. 1979. Production performance of two-way and three-way strain crosses of White Leghorn. Indian Journal of Poultry Science, 14: 114-119.

Nandi, B., L. Samal, N.C. Behura, G.D. Nayak, and D.P. Das. 2017. Growth, efficiency and body conformation traits of Hansli breed of Odisha under intensive management system Journal of Entomology and Zoology Studies. 5(6): 2398-2403

Narayanankutty, K., Churchil, R. R., Anitha, P and Sharma, R.P. 2008. Genetic parameters for egg production and associated traits in two long terms selected strains of White Leghorn. Indian Journal of Animal Genetics and Breeding. 27(1,2): 44-48.

Narayanankutty, K., Churchil, R.R., Praveena, P.E. and Joseph, P. 2009. Effects of strain and egg weight on fertility and hatchability traits in White Leghorn birds. Indian Veterinary Journal, 86(12): 1239-1240.

Narayanankutty, K., Churchil, R.R., Praveena, P.E. and Karim, R. 2010. Fertility, hatchability and embryonic mortality pattern of defective eggs in White Leghorn chicken. Indian Veterinary Journal, 87(3): 293-294.

Narayanankutty, K., Peethambaran, P.A. and Ramakrishnan, A. 1992. Influence of bird density on layer performance. Journal of Veterinary and Animal Sciences, 23(2): 10-13.

Narayankutty, K., Joseph, L. and Ramakrishnan, A. 1994. Effect of floor space on layer performance under wire floor system of rearing. Journal of Veterinary and Animal Sciences, 25.

Nayak, G.D., Behura, N.C., Sardar, K.K. and Mishra, P.K. (2015). Effect of climatic variables on production and reproduction traits of coloured broiler breeder poultry. Veterinary World, 8: 472-477.

Nema, R.P., Bhardwaj, J.K., Atkare, S.S. and Paradkar, N.G. 1996. Influence of divergent body size on body weight, egg weight and egg production after post induced rest period in caged broiler dwarf dams. Proceedings world poultry congress, 2-5 Sept. 96. New Delhi, India. pp. 411-412.

Nema, R.P., Das, S.K., Bhardwaj, J.K. and Atkare, S.S. 2005. Effect of sunflower

Nema, R.P., Das, S.K., Bharwaj, J.K. and Atkare, S.S. 2005. Line, sunflower meal level and their interaction effect on egg quality traits of dwarf. Proc. XXIII IPSA con. 2-4 Feb. Hyderabad, pp. 98.

Nema, R.P., Khan, A.G., Bhardwaj, J.K. and Shrivastava, P.N. 1983. Genetic aspects of feed utilization in White Leghorn strains. Indian J. Anim. Sci. (54)(11) : 1098-1100.

Nema, R.P., Khan, A.G., Singh, S.K. and Poulose, M.V. 1984. Time trend in feed efficiency of two strains of White Leghorn breed. Indian J. Poultry Sci. 19 (2): 85-88.

Nema, R.P., Khan, A.G., Singh, S.K. and Poulose, M.V. 1984. Time trend in feed efficiency of two strains of white Leghorn breed. Indian J. Poult. Sci. 19(2) 65-88.

Nema, R.P., Roy, P. and Atkare, S.S. 2001. Effect on feed utilization traits by feed restriction and supplimentation of methionine. Lysine and choline. 1st South Asian Regional Poultry conference. 24-26. Sept. Pune. India. conference proceedings. Floppy disc. pg. 1.

Nema, S. and Bhardwaj, J.K. 1998. Genotype temperature x housing condition interaction on growth performance of commercial broiler from dwarf dam under summer season. National Semi. on Tech. Ad. In Agril. And livestock Prod. in M.P. JNKVV, Jabalpur 20-22.

Nema, S., Bhardwaj, J.K. and Nema, R.P. 1996. Some Physiological studies on two colour variants of normal bodied broiler dams. World P. Congress. New Delhi, India. 2-5 Sept. IV: 116.

Niraj Kumar, Sushil Prasad and Ravindra Kumar. 2018. "Performance of three way cross dual purpose bird under different system of management", Int. J. Cure. Microbio.App.Sci. special issue-7 :679-685

Niraj Kumar, Sushil Prasad, Ravindra Kumar and Shailendra Rajak 2018 Evaluation of reproductive parameters of dual purpose three way cross (Jharsim) chicken under different management system, Int. J. Cure. Microbio.App.Sci. special issue-7 :686-690.

Niraj Kumar, Sushil Prasad, Ravindra Kumar and Shailendra Rajak, 2020 "Evaluation of three-way cross 'jharsim' varity of chicken under different system of management." Indian journal of animal science 90(9): 1325-1327 September short communication.

Nishant Patel , Bablu Sundi, Sushil Prasad, Ravindra Kumar and Banani Mandal Growth Performance of Vanaraja Birds under Different System of Management, Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-7: 691-695

Nishant Patel , BabluSundi, Sushil Prasad, Ravindra Kumar and Banani Mandal 2018. "Growth performance of vanaraja birds under different system of mangement," Int. J. Cure. Microbio.App.Sci. special issue-7 :691-695

Nishant Patel , BabluSundi, Sushil Prasad, Ravindra Kumar and Banani Mandal 2018. Reproductive and egg quality traits of vanaraja birds under different system of management, Int. J. Cure. Microbio.App.Sci. special issue-7 :696-699.

Nishant Patel, A.K. Shrivastava, Ravindra Kumar, Sushil Prasad, 2014. Carcass characteristics of Grampriya birds under farm and village management condition, Progressive research, 9 (1) : 82-84.

Nishant Patel, Dilip Kumar Jha, Sushil Prasad, 2013. Carcass characteristics of Grampriya birds under different system of management, Indian j. Anim. Prod. Mgmt. Vol. 29(3-4) 41-45.

Nishant Patel, S.K. Srivastava, Ravindra Kumar and Sushil Prasad 2014 Performance of Grampriya birds under farm and village management condition in Chotanagpur, Indian vet. Jour., 92(11) : 71-74 (2014)

Paleja, H.I., Khanna, K., Savaliya, F.P., Joshi, R.S., Patel, A.M and Solanki J.V. 2008. Mathematical model for four weekly egg production in IWN line of White Leghorn. Indian J. Poult. Science 43 (2) : 165-167.

Paleja, H.I., Savaliya, F.P., Patel, A.B., Khanna, K., Vataliya, P.H. and Solanki J.V. 2008. Genetic parameters in White Leghorn (IWN line) chicken. Indian J. Poult. Science 43 (2): 151-154.

Pandey, A., Bhardwaj, J.K., Chakrabarti, R.L. and Paradkar, N.G. 1998. Effect of genotype, stocking density and protein level in conformation traits of commercial broilers, National Semi. on Tech. Ad. In Agril. And livestock Prod. in M.P. JNKVV, Jabalpur 20-22, April, p. 77.

Pandey, S., Khan, A.G. and Nema, R.P. 1995. Production efficiency of dwarf hybrid layer under summer heat. Indian J. Poultry Sci. 65(7) : 785-789.

Pandey, S.S., Behura, N.C., Samal, L., Pati, P.K. and Nayak, G.D. 2018. Evaluation of juvenile growth, feed efficiency and body conformation traits of Native×CSFL crossbred chicken under intensive system of rearing. International Journal of Current Microbiology and Applied Sciences, 8(6): 194-202. doi: https://doi.org/10.20546/ijcmas.2018.705.394

Pandey, S.S., Behura, N.C., Samal, L., Pati, P.K. and Nayak, G.D. 2018. Comparative evaluation of carcass characteristics and physico-chemical and sensory attributes of meat of Native×CSFL crossbred chickens and commercial broilers. International Journal of Livestock Research, 8(6): 194-202. doi: http://dx.doi.org/10.5455/ijlr.20170909061908

Pandey, S.S., Behura, N.C., Samal, L., Pati, P.K. and Nayak, G.D. 2018. Evaluation of juvenile growth, feed efficiency and body conformation traits of Native×CSFL crossbred chicken under intensive system of rearing. International Journal of Current Microbiology and Applied Sciences, 8(6): 194-202. doi: https://doi.org/10.20546/ijcmas.2018.705.394

Pandey, Sonal, Sahni, Y.P, Gautam Vidhi and Jain Sachin Kumar 2014. Efficacy of indigenous herbs Withania somnifera and Emblica officinalis on egg yolk cholesterol in birds. Journal of Veterminary Pharmacology and Toxicology, 3(1): 13-15.

Paradkar, N.G., Atkare, S.S., Nema, R.P. and Poulse, M.V. 1996. Time trend analysis on poultry population in different agroclimatic zones of Madhya Pradesh, national seminar on poultry science, Poultry production in 2000. A.D. Prospects and challanges 18-19 April, Tamil Nadu Vety. Ani Sci. University ppm-4.

Paradkar, N.G., Bhardwaj, J.K., Nema, R.P. and Atkare, S.S. 1996. Poultry improvement in sectors of Madhya Pradesh during post two decades proceedings, World Poultry Congress 2-5 Sept. 96, New Delhi, pp. 457.

Paradkar, N.G., Jain, S.K., Nema, R.P. and Atkare, S.S. 1999. Risk management economics Journal 1(3) pp. 99.

Parihar, G.H. and Bhardwaj, J.K. 2000. Effect of feeding dried poulty excreta enzymes and their interaction with growth and feed efficiency of commercial broilers produced from dwarf broiler dam. JNKVV Res. J. 34(1 & 2) 48-53.

Patel, A.B., Khanna, K., Savaliya, F.P., Paleja, H.I., Joshi, R.S. and Hirani, N.D. 2017. Effect of enzyme supplementation on egg production performance of two strains of White Leghorn chicken. Indian Journal of Poultry Science, 52(2): 178-183.

Patil, M.V., Bhardwaj, J.K., Atkare, S.S. and Nema, R.P. 2013. Conformation traits of coloured broiler as influenced by protein, enzyme and phytobiotics. Proceedings of xxx conf. and National Symposium of IPSA 22-23 Nov. CARI, Izatnagar. Abstr. PNF 061: 160.

Patil, M.V., Bhardwaj, J.K., Atkare, S.S. and Nema, R.P. 2013. Edible yields of coloured broilers fed varying protein diet with enzyme and probiotic. Proceedings of xxx conf. and National Symposium of IPSA 22-23 Nov. CARI, Izatnagar. Abstr. PNF 062: 161.

Patil, M.V., Bhardwaj, J.K., Atkare, S.S. and Nema, R.P. 2013. Effect of protein x enzyme x probiotic interaction on performance of multicoloured broilers. Proceedings of xxx conf. and National Symposium of IPSA 22-23 Nov. CARI, Izatnagar. Abstr. PNF 060: 160.

Patil, M.V., Bhardwaj, J.K., Atkare, S.S. and Nema, R.P. 2013. Effect of protein, enzyme and probiotics on growth performance of coloured broilers. Proceedings of xxx conf. and National Symposium of IPSA 22-23 Nov. CARI, Izatnagar. Abstr. PNF 064: 162.

Patra, A.L., Samal, L., Behura, Sahoo, N., Das, D.P., Champati, A., Muduli, S. and Popalghat, H.K. 2022. Feed and nutrient utilization efficiency and juvenile traits of Vezaguda chicken of Odisha in floor rearing system. The Indian Journal of Animal Sciences, 92(12):1445-1450. https://doi.org/10.56093/ijans.v92i12.102484

Peethambaran, P.A. and Narayanankutty, K. 1999. Effect of bird density on egg quality traits under wire floor system of rearing. Journal of Veterinary and Animal Sciences, 30: 42-44.

Peethambaran, P.A. and Narayanankutty, K. 1999. Influence of cage density on egg quality traits. Journal of Veterinary and Animal Sciences, 30: 48-50.

Peethambaran, P.A. and Narayanankutty, K. 1999. Performance of White Leghorn layers in cages. Journal of Veterinary and Animal Sciences, 30: 32-34.

Peethambaran, P.A. and Narayanankutty, K. Effect 1999 of seasons on layer performance on wire floor system of rearing. . Journal of Veterinary and Animal Sciences, 30: 45-47.

Peethambaran, P.A., Narayanankutty, K. and Nair, G.R. 1998. Effect of bird density on performance of White Leghorn hens in cages. Journal of Veterinary and Animal Sciences, 29: 12-15.

Peethambaran, P.A., Narayanankutty, K. and Nair, G.R. 2001. Production performance of White Leghorn layers on wire floor system of rearing. Journal of Veterinary and Animal Sciences. 32.

Pillai, S.K., Bhardwaj, J.K., Nema, R.P. and Atkare, S.S. 2009. Effect of genotype and nutrition regime on carcass characteristics of multi coloured broiler. Proceedings of xxx conf. and National Symposium of IPSA 22-23 Nov. CARI, Izatnagar. Abstr. PNF 060 : 160.

Pillai, S.K., Bhardwaj, J.K., Nema, R.P. and Atkare, S.S. 2009. Genotype x protein x energy interaction effect on conformation traits of multi coloured broiler. XXV Annual conf. and National Sympo. of IPSA, 10-12 Dec., 2008. Vety College, Anand Agri. Univ. Gujrat, pp. Abst. 139, p. 485.

Ponnuvel, P. and Chacko, B. 2017. Effect of phytase supplementation in low energy layer diet on availability of certain trace minerals. International Journal of Advanced Research in Biological Sciences, 3(7): 31-35.

Ponnuvel, P. and Narayanankutty, K. 2013. Performance of Athulya strain under Kerala climatic condition. The Indian Journal of Field Veterinarians, 9(1): 43-44.

Ponnuvel, P. and Narayanankutty, K. 2014. Effect of phytase enzyme supplementation in low energy-protein layer diet on tibial mineral contents. Journal of Animal Research, 4(2): 211-216.

Ponnuvel, P. Narayanankutty, K., Jalaludeen, A. and Anitha, P. 2015. Effect of phytase supplementation in low energy-protein diet on the production performance of layer chicken. The Indian Journal of Veterinary Sciences and Biotechnology, 10(3): 25-27.

Ponnuvel, P., Anitha, P. and Chacko, B. 2018. Effect of low energy-protein and low phosphorus diets on the production performance of layer chicken. International Journal of Advanced Research in Biological Sciences, 5(1): 1-4.

Ponnuvel, P., Jalaludeen, A. and Ramakrishanan, A. 2001. Influence of cellulase enzyme supplementation in high fibre diet on the production performance of layer chicken. Indian Journal of Poultry Science, 36(1): 54-57.

Ponnuvel, P., Jalaludeen, A. and Unni, A.K.K. 2002. Influence of cellulase enzyme supplementation in high fibre diet on nutrient utilization in layer chicken. Indian Journal of Poultry Science, 37(1): 93-95.

Ponnuvel, P., Narayanankutty, K. and Anitha, P. 2014. Effect of phytase enzyme supplementation in low energy and low protein diets on the production performance of layer chicken. The Indian Journal of Field Veterinarians, 9(4): 39-42.

Ponnuvel, P., Narayanankutty, K. and Anitha, P. 2014. Effect of phytase enzyme supplementation in low energy-protein layer diet on egg quality traits. Journal of Animal Research, 4(1): 115-120.

Ponnuvel, P., Narayanankutty, K., Jalaludeen, A. and Anitha, P. 2014. Economics of phytase enzyme supplementation in low energy-protein layer chicken diet. International Journal of Livestock Production, 5(7): 113-116.

Ponnuvel, P., Narayanankutty, K., Jalaludeen, A. and Anitha, P. 2014. Economics of phytase enzyme supplementation in low energy-protein layer chicken diet. International Journal of Livestock Production, 5(7): 113-116.

Ponnuvel, P., Narayanankutty, K. and Anitha, P. 2014. Effect of phytase enzyme supplementation in low energy-protein layer diet on egg quality traits. Journal of Animal Research, 4(1):115-120.

Poulose, M.V. and Sathe, B.S. 1973. Comparative studies on some economic traits of three exotic strains of W. L. Breed. Third all India Poultry Science Symposium. December 21-24, Page 46-48.

Poulose, M.V. Khan, A.G. Atkare, S.S. and Shrivastava, P.N. 1988. Direct and correlated response to back crossing and selection in small bodied dwarf broiler population. Indian J. of Animal Science, 58(1) : 1302-1306.

Prabhakaran, K.B., Jalaludeen, A., Unni, A.K.K. and Peethambaran, P.A. 2001. Production traits in White Leghorn Strains. Indian Journal of Animal Sciences, 71(8): 810-811.

Prabhakaran, K.B., Jalaludeen. A., Unni, A.K.K. and Leo Joseph. 2000. Genetic evaluation of White Leghorn strains for egg weight. Indian Journal of Animal Sciences, 70(6): 656-658.

Prabhu, G.A., Dutta, I.C. and khan, A.G. 1979. Influence of Genetic and environemental factor upon volume and PH of WLH COCKS. Ind. Poultry Review. 10 : 7 : 23-25.

Prabhu, G.A., Dutta, I.G. & Khan, A.G. 1978. Studies on some physio-chemical attributes and Bio-Chemical constituents of Seminal plasma of chicken. Ann. Sym. Indian Poult. Sci. P-60.

Prajapati A.P., V. Mudgal, J.K. Bhardwaj, R.P. Nema and S. Shrivastav (2010). Effect of copper supplementation on the growth performance of coloured birds. XXVII Annual conf. & National Symposium 16-18th Set., IPSA Conf. 2010, TNVASU,Chennai. XXVII Annual conf. & National Symposium 16-18th Set., IPSA Conf. 2010, TNVASU, Chennai, Abstr. PNR-062.

Prakash, B., Verma, S.K., Rama Rao, S.V., Raju, M.V.L.N., Paul, S.S., Kanan, A., Mishra, S., Singh, V. & Sankhyan, V. (2019). Feeding status of free range scavenging chickens in different agro-climatic regions of India. British Poultry Science, DOI: 10.1080/00071668.2019.1671956

Prasoon, S., Anitha, P., Vimal, A.M., Harikrishnan, S. and Arun, R.U. 2014. Egg production performance of progenies of Australorp with three different strains of White Leghorn. International Journal of Scientific Research. 3(8): 72-74.

Qadri, F.S., Savaliya, F.P., Patel, A.B., Joshi, R.S., Hirani, N.D. and Patil, S.S. 2013. Genetic study on important economic traits in two strains of White Leghorn chicken. Indian Journal of Poultry Science, 48(2): 149-153.

Rajput, D.S., Nema, R.P., Bhardwaj, J.K., Atkare, S.S., Goyal, G. and Baghel R.P.S. 2014. Effect of housing system, dietary energy and dried garlic powder on conformation and carcass characteristics of commercial dual purpose coloured chicks PPT 07(0).

Rath, M. Khan, A.G., and Poulose, M.V. 1980. Studies on body weight reduction attributes of sex –linked recessive dwarfing gene for chicks hatched. From normal White Leghorn dams. Indian J. Anim. Sci. 50: 0: 867 – 871.

Raut, S.N. and Nema, R.P. 1998. Comparative evaluation of certain economic traits under summer season. National Semi. on Tech. Adv. In Agril. And livestock Prod. in M.P. JNKVV., Jabalpur 20-2 April, pp. 77-78.

Reddy, T.S., Nema, R.P. and Atkare, S.S. 2000. Dwarf broiler breeder line X dietary protein and energy interaction effect on performance and feed utilization traits. XX Annual conference and symposium of Indian Poultry Science Association, Oct., 12-14, 2000. Tamil Nadu Vety. & Ani. Sci. University, Tamil Nadu PGB. 14 pp-30.

Reen, J K, Katoch S, Sankhyan V and Thakur Y P. 2014. Molecular characterization of Native chicken of Himachal Pradesh using Microsatellite Markers. Veterinary Practitioner, 15 (8): 195-198.

Reen, J K, Sankhyan V, Katoch S and Thakur Y P. 2013). Candidate gene polymorphism for IL-2Ry and ChB6 genes in indigenous chicken of north- Western Himalayan state of Himachal Pradesh, India. Poultry Science Journal 1(2): 87-92.

Rehade, K.S., Nema, R.P., Bhardwaj, J.K., Atkare, S.S., Goyal, G. and Baghel, R.P.S. 2014. Effect of replacement of inorganic minerals with chelated minerals and protein on conformation traits of coloured chicks, PPT 21(0).

Rehpade, K.S., Nema, R.P., Bhardwaj, J.K., Atkare, S.S.,Goyal, G. and Baghel, R.P.S. 2014. Effect of replacement of inorganic minerals with chelated minerals and protein on body weight, feed intake and food conversion rate of colour chicks, PNF 67(0).

Sahasnani, M.N., Savaliya, F.P., Khanna, K., Patel, A.B., Patel, J.S., Joshi, R.S. and Patil, S.D. 2013. Effect of different protein and energy levels on production performance of laying hens. Indian Journal of Poultry Science, 48(2): 173-177.

Sahoo, D.P., N.C. Behura, L. Samal, B. Nandi, J. Bagh, G.D. Nayak, and P.K. Pati 2017. Growth performance, feed efficiency and linear body measurements of triple cross progenies of Hansli, CSML and CSFL chickens E-planet; 15(2): 127-132

Sahoo, D.P., Behura, N.C., Samal, L., Bagh, J., Nandi, B., Nayak, G.D. and Pati, P.K. 2018. Evaluation of carcass traits and meat composition of triple cross progenies of Hansli, CSML and CSFL chickens. International Journal of Current Microbiology and Applied Sciences, 7(1): 1801-1807. doi: https://doi.org/10.20546/ijcmas.2018.701.218.

Sahoo, N., Bhuyan, K., Panda, B., Behura, N.C., Biswal, S., Samal, L., Chaudhary, D., Bansal, N., Singh, R., Joshi, V.G., Jindal, N., Mahajan, N.K., Mann, S., Ravishankar, C., Ravindran, R., Radzio-Basu, J., Herzog, C.M., Kapur, V., Mor, S.K. and Goyal, S.M. 2022. Prevalence of Newcastle disease and associated risk factors in domestic chickens in the Indian state of Odisha. PLoS ONE 17(2): e0264028. https://doi.org/10.1371/journal.pone.0264028

Sahu, A.K., Khan, A.G. and Dave B.K. 1983. Seminal attributes of dwarf and white leghorn males. Indian J. Poult. Sci. Vol. 18:117-118.

Saini S and Bajwa IS 2015 Incidence of split feathers and its association with carcass, conformation and bilateral asymmetry traits in male broiler chicken. Indian Journal of Animal Research 49(4): 429-433.

Samal, L. 2019. Garlic (Allium sativum) In: Phytobiotics and Animal Production (Ed.) Singh, P.K., International Books & Periodical Supply Service, Delhi, India. Chapter 9. pp. 183-204.

Samal, L. 2020. How to increase the income of livestock farmers in India? PashudhanPraharee. https://www.pashudhanpraharee.com/how-to-increase-the-income-of-livestock-farmers-in-india-17/

Samal, L. 2020. Scope of backyard poultry farming in Odisha. PashudhanPraharee. http://www.pashudhanpraharee.com/scope-of-backyard-poultry-farming-in-Odisha/

Samal, L. 2020. Veterinary homeopathy. PashudhanPraharee. https://www.pashudhanpraharee.com/veterinary-homeopathy/

Samal, L. and Behura, N.C. 2019. Ginger (Zingiber officinale). In: Phytobiotics and Animal Production (Ed.) Singh, P.K., International Books & Periodical Supply Service, Delhi, India. Chapter 16. pp. 307-326.

Samal, L., Krishnan, G., Bagath, M., Sejian, V., Malik, P.K. and Bhatta, R. 2021. Climate Change adaptation in Animal Agriculture. In: Climate Resilient Animal Agriculture (Eds.) Rao, G.S.L.H.V.P., Varma, G.G. and Beena, V. Nipa Publishing. Chapter 01. pp. 1-20.

Sankaralingam, S., Unni, A.K.K. and Leo Joseph. 1998. Influence of different serum alkaline phosphatase type matings on reproduction traits in IWP and IWN strains of White Leghorn. Indian Journal of Poultry Science, 33(2): 132-136.

Sankaralingam, S., Unni, A.K.K. and Reghunandanan, K.V. 1998. Serum alkaline phosphatase polymorphism and its association with production traits in IWP and IWN strains of White Leghorn. Indian Journal of Poultry Science, 33(2): 124-131.

Sankaralingam, S., Unni, A.K.K. and Reghunathan, G. 1998. Serum alkaline phosphatase polymorphism and its association with SAP level and egg quality traits in IWP and IWN strains of White Leghorn. Indian Journal of Poultry Science, 33(3): 352-354.

Sankhyan V and Thakur YP. 2016. Comparative Performance of Vanaraja and Indigenous Chicken under intensive system in sub temperate climatic condition of north western Himalayan state of Himachal Pradesh. International Journal of Science Environment and Technology, 5(2): 449-453.

Sankhyan V, Katoch S, Thakur Y P and Thakur R. 2013. Rural Poultry Production Status & Headway Option for Betterment in Himachal Pradesh- An Overview Himachal Veterinary Journal Vol 6(1) 2013: 17-27.

Sankhyan V, Katoch S, Thakur Y P, Dinesh K, Patial S and Bhardwaj N. 2013. Analysis of characteristics and improvement strategies of rural poultry farming in north western Himalayan state of Himachal Pradesh, India. Livestock Research for Rural Development. 25 (12), Article #211. Retrieved from http://www.lrrd.org/lrrd25/12/sank25211.html.

Sankhyan V, Thakur YP, Katoch S and Dogra PK. 2015. Factors affecting fertility, hatchability and chick survivability in poultry germplasm under sub-temperate conditions. Himachal Journal of Agricultural Research 41 (1): 83-85.

Saroori, A.R., Nema, R.P., Bhardwaj, J.K., Atkare, S.S. and Baghel, R.P.S. 2010. Evaluation of crossbred kadaknath at middle age of production. PYMP-004 p. 220.

Saroori, A.R., Nema, R.P., Bhardwaj, J.K., Atkare, S.S. and Baghel, R.P.S. 2010. Effect of crude protein x energy level interaction on performance of crossbred kadaknath hens. PNR-037, p. 143.

Saroori, A.R; Nema, R.P; Bhardwaj, J.K; Atkare, S.S. and Baghel, R.P.S. 2010. Performance of crossbred kadaknath hens at middle age of production fed with varying dietary regimes. PNR – 064, P. No. 112.

Savaliya, F. P., Rank, D. N., Vataliya, P. H., Khanna, K. and Shukla, R. K. 1992. Study of the heterosis effect in Serum Alkaline Phosphatase (SAP) level and various economic traits in White Leghorn strain crosses. XIX World Poult. Cong. 20-24 Sept. p. 742. Amsterdam, Netherlands.

Savaliya, F. P., Rank, D. N., Vataliya, P. H., Khanna, K. and Shukla, R. K. 1992. Study of reciprocal effect in Serum Alkaline Phosphatase level (SAP) and various economic traits in White Leghorn strain crosses. XIX. World Poult. Cong. 20-22 Sept. p.741, Amsterdam, Netherlands.

Savaliya, F. P., Shukla, R. K., Khanna, K., Brahmkshtri, B. P. 1997. Inheritance of serum alkaline phosphatase level and certain economic traits in pure and reciprocal crosses of White Leghorn strains. Indian. J. Anim. Sci. 67 (2): 156-157.

Savaliya, F. P., Shukla, R. K., Khanna, K., Brahmkshtri, B. P., Rank, D. N., Mishra, R. K. and Joshi, R. S. 1996. Heterosis and reciprocal effects on serum alkaline phosphatase level and certain economic traits in White Leghorn. Indian J. Poult. Sci., 31 (2): 106-109.

Savaliya, F.P., Patel, A.B., Mishra, R. K., Joshi, R.S. and Hirani, N.D. 2014. Inheritance and association among various economic traits of two strains of White Leghorn. Indian Journal of Poultry Science, 49(2): 147-151.

Seema Agarwal, Sushil Prasad, Ravindra Kumar, SoumenNaskar and Subhash Chandra 2021. "Evaluation of egg quality traits of indigenous chiken of chotanagpur plateau of Jharkhand under intensive system," The pharma innovation journal sp- 10(8): 637-639

Senapati, D.K., N.C. Behura, L. Samal, P.K. Mishra, S.K. Mishra, and B. Panigrahi 2017. Effects of growth curves on performance, egg production and egg quality traits in broiler breeder hens Advances in Bioresearch; 8 (6): 118-126

Senapati, D.K., N.C. Behura, L. Samal, P.K. Mishra, S.K. Mishra, and B. Panigrahi 2017. Effects of growth curves on performance and body conformation traits in broiler breeder pullets Advances in Bioresearch 8 (6): 25-33

Sharma D, Mahajan K, Agnihotri RK, Katoch S and Sankhyan V. 2010. Effect of malathion and deltametharine on natural infestation of lice and mites of desi Fowl of Himachal Pradesh. Himachal Journal of Agricultural Research 36(2):226-228

Sharma S, Singh G, Vij R, Sankhyan V and Dinesh K 2021. Physical and Biochemical Characterization of Eggs of Chicken

Crossbreed and Its Comparison with Dahlem Red for Rural Poultry Development. Asian Journal of Dairy and Food Research.2021. (40):466-470.

Shashi Bharti, Rakhi, Vaish, Nidhi Gupta, Yogita Pandey and R.P. Singh 2018. Comparative study on histomorphology of magnum in laying kadaknath and White Leghorn Fowl. Journal of Entomology and Zoological Studies, 6(3): 1442-1445.

Sheikh, I. U., Kalita, N., and Mahanta, J. D. 2018. "Economic analysis of Indigenous, Vanaraja, and crossbred (PB2xIndigenous) chickens under intensive system of rearing." Journal of Entomology and Zoology Studies, 6(5), 359-362.

Sheikh, I. U., Kalita, N., Mahanta, J. D., and Hussain, J. 2018. "Studies on certain egg qualities of Indigenous, Vanaraja, and crossbred (PB2xIndigenous) chickens under Intensive and Backyard systems of rearing." International Journal of Current Microbiology and Applied Sciences, 7(4), 1690-1695.

Sheikh, I. U., Kalita, N., Mahanta, J. D., Barua, N., Ahmed, M., and Das, G. C. 2016. "Comparative study on the carcass characteristics of Indigenous, Vanaraja, and crossbred (Pb2xIndigenous) chickens under intensive and backyard systems of rearing." The Proceedings of XXXIII IPSACON 2016, Abstract No OP-I.08, 41.

Shrivastav, Arpita, Sharma, R.K., Sahni, Y.P., Shrivastav, N., Gautam, V. and Jain, Sachin Kumar 2016. Study of antimicrobial resistance due to ESBL producing E. coli in broilers. XVI Annual conference of ISVPt and National symposium on "Animal Health and Production Challenges and opportunities in Veterinary Pharamacology and Toxicology p. 108, College of Veterinary Science and A.H., NAU, Navsari, Gujarat, 23-25 November, 2016.

Shrivastav, Arpita, Sharma, R.K., Sahni, Y.P., Shrivastav, Neeraj, Gautam, Vidhi and Jain, Sachin 2018. Study of antimicrobial resistance due to extended spectrum beta lactamase producing Escheichia coli in healthy broilers and Jabalpur colour bird. Veterinary World, 9(11): 1259-1263.

Shrivastav, Arpita, Sharma, R.K., Sahni, Y.P., Shrivatav, N., Sharma, V., Gautam, V. and Jain, Sachin Kumar 2016. Study of inhibitory potential and percent inhibition of oil of Syzigium aromaticum and leaves of Ocimum sanctum on extended spectrum beta lactamase enzyme from E coli of broilers in Jabalpur. XVI Annaul confernece of ISVPT and National symposium on "Animal Health and production: Challenges and opportunities in Veterinary Pharmacology and Taxicology pp 72-73, Gujarat, 23-25 November, 2016.

Singh P, Bajwa IS and Saini S 2014. Evaluation of haematocrit, thermoregulation and in vitro hsp70 gene expression in selected and control broiler lines. Indian Journal of Poultry Science 49(2): 140-143.

Singh P, Bajwa IS, Brah GS and Saini S 2012. Effect of selection for increased body weight on humoral and in vivo cell mediated response in broiler chicken. Indian Journal of Poultry Science 47(3): 292-294.

Singh P, Bajwa IS, Brah GS and Saini S 2012. Evaluation of Humoral and in vivo Cell Mediated Immune Responses in Selected and Control Line of Broiler Chicken. Special Issue of Journal of Crop Improvement (Special issue) for International Conference on "Sustainable Agriculture for Food and Livelihood Security" held on November 27-29, 2012 at Punjab Agricultural University, Ludhiana.

Singh, A.G., Khan, A.G., AND Gehlent, B.S., 1980. The effect of reciprocal crosses between dwarf and normal parents upon the bold. constituents of their progeny Br. Poultry. Sci. 21: 77 – 79.

Singh, B.N., Mukherjee, D.P. and Khan, A.G. 1976. A note on genotype studies on the dimensional characteristics of the erythrocyte and spermatozoan of four strains of White Leghorn breeds. Indian, J. Anim. Sci. 46 (10) : 564-567.

Singh, M.K., Atkare, S.S., Bhardwaj, J.K. Baghel, R.P.S. and Nema, R.P. 2013. Effect of protein, energy and probiotic on certain juvenile growth traits of dual coloured birds. XXX Conf. and national Symposia of IPSA on Poultry Production, 22-23 Nov., 2013, CARI, Izatanagar, Barelly (U.P.), PNF 127: 93.

Singh, M.K., Atkare, S.S., Bhardwaj, J.K. Nema, R.P., Chikwa Kiran, Baghel R.P.S. and Joshi S.K. 2019. Effect of protein, energy and probiotics on juvenile growth and economy of dual colour chicks. The pharma innovation journal 8(3): 394-396.

Singh, M.K., Atkare, S.S., Bhardwaj, J.K., Baghel, R.P.S. and Nema, R.P. 2013. Effect of protein, energy and probiotic levels interaction on performance of dual colour birds reared upto 10th week of age. XXX Conf. and national Symposia of IPSA on Poultry Production, 22-23 Nov., 2013, CARI, Izatanagar, Barelly, PNF 128: 94.

Singh, M.K., Atkare, S.S., Bhardwaj, J.K., Baghel, R.P.S. and Nema, R.P. 2013. Conformation traits of dual coloured birds as influenced by protein energy and probiotics. XXX Conf. and national Symposia of IPSA on Poultry Production, 22-23 Nov., 2013, CARI, Izatanagar, Barelly, PNF 125: 93.

Singh, M.K., Atkare, S.S., Bhardwaj, J.K., Baghel, R.P.S. and Nema, R.P. 2013. Effect of protein x energy x probiotic interaction on conformation traits of dual type coloured birds. XXX Conf. and national Symposia of IPSA on Poultry Production, 22-23 Nov., 2013, CARI, Izatanagar, Barelly, PNF 124: 92.

Singh, S., Atkare, S.S., Bhardwaj, J.K. and Parmar, S.N.S. 2009. Effect of density, protein and amla additive on growth and feed efficiency of broiler during hot humid climate. XXV Annual conf. and National Sympo. of IPSA, 10-12 Dec., 2008. Vety College, Anand Agri. Univ. Gujrat, pp. Abst. 183, p. 482.

Singh, S., Atkare, S.S., Nema, R.P. and Baghel, R.P.S. 2009. Performance of broiler by interaction effect of density, protein and amla addivites. Annual conf. and National Symp. of IPSA, Vety. Colg. Annual Agri. Univ. Gujrat 10-12 Dec., 2008, Abst. 105, p. 428.

Singh, S.K., Atkare, S.S., Bhardwaj, J.K., Baghel, R.P.S. and Jain, A.K. 2010. Performance of broiler reared in different stocking density and fed protein as well as amla (Emblica officinalis) supplemented ration. Indian Journal of Animal Production and Management 26()1-2) 53-55.

Singh, S.K., S.S. Atkare, J.K. Bhardwaj, R.P.S. Baghel and A.K. Jain 2010. Performance of broiler reared in different stocking density and fed protein as well as amla supplemented ration. Indian Jr. of Anim. prod. & management, 26(1-2): 53-55.

Singh, S.S., Khan, A.G. and Shrivastava, P.N. 1978. Genetic correlation between sexual

Singh, Shailendra Atkare, S.S., Bhardwaj, J.K., Nema R.P., Chikwa Kiran, Parmar, S.N.S. and Joshi, S.K. (2019). Effect of density protein and amla fruit power (Entilica officianalis) on broiler performance and litter parameters. The pharma innovation journal, 8(3): 419-421.

Soni, N., Mishra, S.K., Behura, N.C. et al., (2014). Effects of supplementation of organic zinc on the performance of broiler breeders. Animal Nutrition and Feed Technology 14: 359-369.

Sreeveen, E.N., Binoj Chacko, Anitha, P., Sankaralingam, S., Shyama, K., Ancy, M. and Shinde, V. 2018. Influence of sequential feeding on egg production performance of Athulya layer chicken. Journal of Indian Veterinary Association, Kerala 16 (2):80-84.

Suja, C.S., Chacko, B., Anitha, P. and Girijan, G. 2019. Effect of dietary supplementation of marigold petals, red amaranth leaves, curry leaves and turmeric powder on egg yolk pigmentation in native birds of Kerala and White Leghorn layers. Veterinary Research International, 7(3): 146-148.

Sukumar, D. and Jalaludeen, A. 2003. Effect of supplemental phytase in diet on certain economic traits in layer chicken. Indian Journal of Animal Science, 73(12):1357-1359.

Sukumar, D. and Jalaludeen, A. 2012. Dietary phytase supplementation on egg quality traits in White Leghorn strain cross chicken. Journal of Indian Veterinary Association, Kerala, 12(1): 9-12.

Sukumar, D. Jalaludeen, A. and Anitha,P. 2012. Effect of dietary supplementation on certain haematological and and skeletal parameters in White Leghorn strain cross birds. Wayamba Journal of Animal Science, 578X: 475-478.

Sukumar, D., Jalaludeen, A. and Cyriac, S. 2013. Effect of mitigating environmental pollution by incorporation of phytase enzyme in feed of (Athulya) layer chicken. Wayamba Journal of Animal Science, 5: 569-573.

Tanveer Akhtar, A.K. Shrivastava, Ravindra Kumar and Sushil Prasad, 2012. "Egg quality and carcass characteristics of indigenous chicks reared under intensive and backyard system. Progressive Reseach 7 (special) 300-302 .

Tekam, Shashi, Rakhi Vaish, Nidhi Gupta, and Yogital Pandey 2018. Histomorphological studies of left ovary in Kadaknath and White Leghorn pre-hatch chicks. Indian Journal Veterinary Anatomy, 28(2): 80-83.

Thakur R, Sankhyan V, Kumar R and Mankotia BS. 2020. Demonstration on Himsamridhi variety of chicken under rural poultry production in District Kangra, Himachal Pradesh. Journal of Krishi Vigyan. 9(1): 351-54

Veeramani, P. Churchil, R. and Narayanankutty, K. 2012. Estimates of heritability and correlations of economic traits in two strains of White Leghorn. International Journal of Veterinary Science, 1(2): 45-48.

Veeramani, P., Narayanankutty, K. and Churchil, R.R. 2008. Estimation of heritability and correlation of economic traits in IWP strain of White Leghorn chicken. Indian Journal of Animal Research, 42(4): 257-260.

Verma, A.K. and Khan, A.G. 1982. Influence of dw gene on post maturity body weights and sexual maturity of 'Narmada – XL' egg layer, and dwarf and broiler pullets. Indian J. Anim. Sci. 53(9): 973-977.

Verma, A.K. and Khan, A.G. 1983. Influence of dw gene on post maturity body weights and sexual maturity of 'Narmada-XL' egg layer and dwarf and broiler pullets. Indian J. Anim. Sci. 53 (9) 973-977.

Viswanath, A., Singh, R., Unni, A.K.K. and Kurian, G. 1984. Egg parameters in 3x3 diallel crosses of three strains of White Leghorn birds. Kerala Journal of Veterinary and Animal Sciences, 15: 119-125.

Thesis (PG and PhD)

Sl No.	Year	Title	Degree	Student	Major advisor
KVASU, Kerala					
1	1976	Studies on the water restriction in caged layers	M.V.Sc.	Dr. A. Jalaludeen	Dr. A. Ramakrishnan
2	1978	Evaluation of dried poultry manure in layer ration.	M.V.Sc.	Dr. P.A. Peethambaran	Dr. C. K. Venugopalan
3	1978	Comparative study on the production characteristics of White Leghorns in cages and on litter (1978).	M.V.Sc.	Dr. T.N. Balachandran	Dr. A.K. K. Unni
4	1979	Economics of raising White Leghorn chicks for meat.	M.V.Sc.	Dr. Maria Liza Mathew	Dr. C. K. Venugopalan
5	1981	Keeping quality of shell eggs during summer	M.V.Sc.	Dr. R. Radhakrishnan Nair	Dr. C. K. Venugopalan
6	1983	Genetic effect influencing egger traits from diallel mating system	M.V.Sc.	Dr. K. Rash Behari Singh	Dr. A. K. K. Unni
7	1991	Studies on capon production	M.V.Sc.	Dr. Jyothirmoy Chakraborthy	Dr. R. S. Nair
8	1991	Effect of housing system on protein and energy requirements of White Leghorn	M.V.Sc.	Dr. P. Anitha	Dr. A. Jalaludeen
9	1992	Effect of floor density on production performance of commercial hybrid layers	M.V.Sc.	Dr. A. G. Geo	Dr. Amritha Viswanath
10	1995	Influence of pullet body weight on production traits in White Leghorn	M.V.Sc.	Dr. A. S. Sudheesh Kumar	Dr. Leo Joseph
11	1996	Egg weight profile in three strains of White Leghorn.	M.V.Sc.	Dr. K. B. Prabhakaran	Dr. A. Jalaludeen
12	1997	Influence studies on serum alkaline phosphatase and haemoglobin in two strains of White Leghorn	M.V.Sc.	Dr. S. Sankarlingam	Dr. A. K. K. Unni
13	1999	Effect of phytase supplementation on Phosphorus utilisation and performance in layer chicken	M.V.Sc.	Dr. D. Sukumar	Dr. A. Jalaludeen
14	2004	Production performance of reciprocal crosses of White Leghorn strains under deep litter system (2004)	M.V.Sc.	Dr. K. Giriraj .	Dr. A. Jalaludeen
15	2013	Performance of progenies of Australorp with F, N and P strains of White Leghorn	M.V.Sc.	Dr. Prasoon S.	Dr. P. Anitha
16	2015	Performance of crossbred layers of Australorp and Rhode Island Red with genetically improved strains of White Leghorn under backyard system	M.V.Sc.	Muhammed Afzal A.	Dr. P. Anitha
17	2016	Identification of SNPs of *ovocalyxin-32* gene in IWN strain of White Leghorn and its association with production traits	M.V.Sc.	Dr. Greeshma Girijan	Dr. S. Sankaralingam
18	2017	Association of polymorphism of *prolactin* gene with production traits of White Leghorn and Native chicken	M.V.Sc.	Dr. Azhaguraja M.	Dr. S. Sankaralingam
19	2018	Influence of sequential feeding on egg production performance of Athulya layer chicken	M.V.Sc.	Dr. Sreeveen E.N.	Dr. Binoj Chacko
20	2019	Influence of fish oil on production performance and fatty acid profile of eggs in Athulya and Native chicken	M.V.Sc.	Dr. Arsha V.S.	Dr. Binoj Chacko

Sl No.	Year	Title	Degree	Student	Major advisor
21	2021	Evaluation of production performance of Athulya (IWN X IWP), Native and IWN X Native crossbred layers under backyard system.	M.V.Sc.	Dr. Devavratha S.	Dr. Binoj Chacko
22	2022	Enrichment of chicken egg by dietary inclusion of flaxseed oil, fish oil and their combination	M.V.Sc.	Dr. Archana S.	Dr. S. Sankaralingam
23	1986	Calcium and phosphorus requirement of caged layers	PhD	Dr. T. C. Brahma	Dr. A. Ramakrishnan
24	1986	Dietary protein and Energy requirement of caged layers	PhD	Dr. A. Jalaludeen	Dr. A. Ramakrishnan
25	1986	Selection studies in chicken for egg number on part records	PhD	Dr. Maheswar Rath	Dr. A. K. K. Unni
26	2013	Supplementation of phytase in low energy-protein diet on production performance of layer chicken	PhD	Dr. P. Ponnuvel and	Dr. K. Narayanankutty
27	2015	Influence of energy level and particle size of feed on production performance of Athulya layer chicken	PhD	Dr. Binoj Chacko	Dr. P. Anitha
28	2019	Selection for egg production in native chicken and performance of its crossbreds with White Leghorn	PhD	Dr. Harikrishnan S.	Dr. Binoj Chacko
KVAFSU, Bengalore					
29	2000	Evaluation of Coloured Broiler Parental Lines for early Growth & Carcass Traits	M.V.Sc.	Amrutesha. S. K	Dr. H. N. Narasimhamurthy
30	2001	Evaluation for Egg Production & Allied Traits in Coloured Broiler Breeder Dam Line	M.V.Sc.	Ashok Mandapurade	Dr. H. N. Narasimhamurthy
31	2005	Body Weight Profile during Feed Restriction in PB – 2 & Control Lines	M.V.Sc.	Prashanth Kumar. G. N	Dr. H. N. Narasimhamurthy
32	2006	Studies on Effects of 2 - α – Bromeorgocriptine (Anti Prolactin Agent) on Production Efficiency of coloured Broiler Breeder Dams	M.V.Sc.	Srinidhi. K. P	Dr. H. N. Narasimhamurthy
33	2011	Evaluation of Nutritive Value of Organic Source of Zinc & Manganese (Mn) in Replacing Inorganic Source on the performance of Coloured Broilers	M.V.Sc.	Bharamappa. H. Korawar	Dr. Jayanaik
34	2012	Effect of Supplementing Organic Source of Iron (Fe) & Copper (Cu) in the Diets on the Performance of Colored Broilers (Raja II)	M.V.Sc.	Mohammad Dawood Shirzad	Dr. Jayanaik
35	2013	Influence of Organic Source of Chromium & Selenium in Coloured Broiler Diet in Designing Functional Meat	M.V.Sc.	Prakash Mirji	Dr. T. Munegowda
36	2013	Characterization & Performance Evaluation of Indigenous Chicken in Mysore Division of Karnataka State	PhD	Gopinath. C. R.	Dr. H. N. Narasimhamurthy
37	2013	Characterization & Performance Evaluation of Indigenous Chicken in Bangalore Division of Karnataka State	PhD	Rajakumar Nagarahalli	Dr. H. N. Narasimhamurthy
38	2016	Comparative evaluation of Giriraja and Raja II under intesive and semi-Intensive system	M.V.Sc.	Nagavat Nemya Naik	Dr. T. Munegowda,
39	2016	Effect of Supplementation of Acidifier on the Performance of Raja II Broilers	M.V.Sc.	Doke Vijay Balaji Rao	Dr. T. Munegowda
40	2016	Effect of Supplementation of various Levels of Inulin on Growth Performance, Cariass Characteristics & Immunity in Raja II Broilers	M.V.Sc.	Praveen. T	Dr. T. Munegowda
41	2017	Efficacy of Feeding different Levels of Multi – Enzymes on Growth, Growth Performance, Carcass Characteristics & Immune Status in Raja II Broilers	M.V.Sc.	Sayyad Irfan Ayub	Dr. T. Munegowda

Sl No.	Year	Title	Degree	Student	Major advisor
42	2017	Effect of Supplementation of Phytobiotic Shastavari (Asparagus Racemosus) on the Performance & Immune Status in Raja II Broilers	M.V.Sc.	Saste Ashwini Shivaji	Dr. T. Munegowda
NDVSU, Jabalpur					
43	1972	Studies on nutritive value of kodo (*Daapalum scorbiculatum*) for growing chicks.	M.V.Sc.	Dr. M.V. Roday	Dr. B.S. Sathe
44	1973	Comparative studies on some economic traits of three exotic strains of White Leghorn breed	M.V.Sc.	Dr. M.V. Poulose	Dr. A.G. Khan
45	1973	Studies on the assessment of protein quality of fish meal and ground nut cake for chick	M.V.Sc.	Dr. S.S. Zombade	Dr. B.S. Sathe
46	1973	Studies on the effect of increasing the bird density and protein level on the performance of layers kept on floor and in cages.	M.V.Sc.	Dr. S.Smalo	Dr. B.S. Sathe
47	1973	Studies on losses in egg quality during different time and temperature of storage and containers used in present marketing channels.	M.V.Sc.	Dr. Y.P. Singh	Dr. B.S. Sathe
48	1974	Comparative studies on some economic traits in crossbred White Leghorn fowl.	M.V.Sc.	Dr. S.P. Khare	Dr. A. G. Khan
49	1974	Strain variation in productive performance of birds house in battery wire cages and deep litter system of management	M.V.Sc.	Dr. D.C. Tripathi	Dr. B.S. Sathe Dr. A. G. Khan
50	1975	Inter strain variation for fertility and hatchability in White leghorn breed.	M.V.Sc.	Dr. Jairam Prasad	Dr. A. G. Khan
51	1975	Inter strain variation for body weight egg weight sexual maturity and part time egg production in sex unselected strains of White leghorn breed.	M.V.Sc.	Dr. A.B. Jha	Dr. A. G. Khan
52	1975	Inter strain variation in sexual dimorphism for juvenile body weight White leghorn breed.	M.V.Sc.	Dr. Jagpal Singh	Dr. A. G. Khan
53	1976	Influence of sexual dimorphism in juvenile body weight on egg production and adult body weight of chicken	M.V.Sc.	Dr. S.S.Singh	Dr. A. G. Khan
54	1976	Inheritance of body weight in White Rock and White Cornish breeds of fowl.	M.V.Sc.	Dr. Vijai Prasad	Dr. A. G. Khan
55	1976	Studies on the performance of purebred and crossbred pullets from four strains of White leghorn breed.	M.V.Sc.	Dr. P.Das	Dr. A. G. Khan
56	1978	Comparative studies on phenotypic and biochemical attributes of sex-linked dwarfing gene dw in broiler population.	M.V.Sc.	Dr. A.B Singh	Dr. A. G. Khan
57	1979	Influence of dwarfing gene on juvenile body weights of normal and dwarf broiler.	M.V.Sc.	Dr. R.D. Gupta	Dr. A. G. Khan
58	1979	Effect of single and double dose of sex-linked recessive dwarfing gene on morphological characteristics and some of the biochemical constituents of fowl spermatozoa.	M.V.Sc.	Dr. S.S. Mondal	Dr. S. Chakraborti
59	1979	Comparative genetical studies on body weights of dwarf and normal egg type chicken.	M.V.Sc.	Dr. M.Rath	Dr. A. G. Khan
60	1980	Effect of successive back crossing on growth rate of dwarf broiler chicken	M.V.Sc.	Dr. K.Khanna	Dr. A. G. Khan
61	1980	Effect of semen characteristics, body weight, deep body temperature on fertility and hatchability of five strains of white leghorn breed	M.V.Sc.	Dr. N.K.Prasad	Dr. A.G.Khan
62	1980	Studies on cholesterol content of blood serum and egg of White leghorn and Narmada –XI breed fed differential nutritional regime.	M.V.Sc.	Dr. D.S.Geete	Dr. A.G.Khan
63	1980	Effect of genotype of dam on body weight of dwarf and normal pullets.	M.V.Sc.	Dr. A.K. Jain	Dr. A.G.Khan

Sl No.	Year	Title	Degree	Student	Major advisor
64	1981	Effect of heterospermi on spermatozoon livability and fertility using dwarf and normal cock semen.	M.V.Sc.	Dr. A.K.Sahu	Dr. A.G.Khan
65	1981	Influence of genotypes and environmental interaction on juvenile growth rate of dwarf chicks under diversified genetic origin.	M.V.Sc.	Dr. P.K.Panda	Dr. A.G.Khan
66	1981	Effect of different protein and energy level on egg production, egg weight and body weight of Narmada –XI dwarf pullets.	M.V.Sc.	Dr. K.K.S.Baghel	Dr. A.G.Khan
67	1981	Influence of sex linked recessive dwarf gene dw on production performance of pullets having diversified polygenic inheritance.	M.V.Sc.	Dr. A.K.Verma	Dr. A.G.Khan
68	1981	Influence of ambient temperature and body weight on some production and biochemical attributes of sex linked recessive dw dwarfing gene.	M.V.Sc.	Dr. R.N.Tiwari	Dr. A.G.Khan
69	1982	Genetic studies on juvenile growth rate, egg weight and sexual maturity in five strains of White Leghorn breed	M.V.Sc.	Dr. J.K.Bhardwaj	Dr. A.G.Khan
70	1982	Genetics of feed utilization in White Leghorn breed.	M.V.Sc.	Dr. R.P.Nema	Dr. A.G.Khan
71	1983	Genetics of viability in White Leghorn breed.	M.V.Sc.	Dr. S.K.Gumasta	Dr. A.G.Khan
72	1983	Influence of sire and dam infertility and hatchability of five strains of White Leghorn breed.	M.V.Sc.	Dr. L.M.Mohapatra	Dr. A.G.Khan
73	1983	Comparative growth studies on Kadaknath and White leg horn fowl	M.V.Sc.	Dr. R.K.Mishra	Dr.V.P.Singh
74	1985	Studies on body weight and plasma uric acid content of dwarf and normal broiler progenies from heterozygous sires for dwarfing gene.	M.V.Sc.	Dr. R.K.S.Bais	Dr.A.G.Khan
75	1985	Influence of dietary iodine supplementation on pullets carrying sex- linked barring B and dwarfing dw gene on production traits of fowl	M.V.Sc.	Dr. K.B.S.Parihar	Dr.A.G.Khan
76	1985	Inter strain variation in production performance of layers type chicks under summer stress.	M.V.Sc.	Dr. M.Y.Singh	Dr. A.G. Khan
77	1985	Genetic analysis for part time egg production in WHITE leghorn breed.	M.V.Sc.	Dr. S.S.Atkare	Dr. A.G. Khan
78	1986	Studies on the nature of genetic variance from 4x4diallele cross of WLH breed.	M.V.Sc.	Dr. Farudur Rehman	Dr.M.V.Poulose
79	1986	Growth studies of inter se dwarf and crossbred normal broiler progenies from normal and dwarf dams	M.V.Sc.	Dr. M.B.Parvekar	Dr.A.G.Khan
80	1987	Direct and correlated responses in IWK strain White Leghorn breed following Os borne selection method.	M.V.Sc.	Dr. C.B.Pandey	Dr.A.G.Khan
81	1988	Influence of deep body temperature on economic traits under summer stress	M.V.Sc.	Dr. A.S.Rathoud	Dr.A.G.Khan
82	1989	Genetic variance and covariance for fertility and hatchability in strains selected for egg production.	M.V.Sc.	Dr. J.B.Kundu	Dr.A.G.Khan
83	1989	Influence of sire carrying sex –linked dwarfing gene on body weight of egg type progenies hatched from dwarf and normal dams.	M.V.Sc.	Dr. P.K.Sinha	Dr.A.G.Khan
84	1990	Studies on effect of housing system, energy and protein level on physical egg quality traits in chicken.	M.V.Sc.	Dr. V.Sathe	Dr.A.G.Khan

Sl No.	Year	Title	Degree	Student	Major advisor
85	1991	Estimation of genetic variances from a 3x3 diallele cross data for egg weight, egg mass and egg quality traits from 56-72 weeks of age in White leghorn layers	M.V.Sc.	Dr. R.K.Mishra	Dr.A.G.Khan
86	1992	Genetic analysis of early growth and reproduction traits of dwarf chicken under White leghorn genome.	M.V.Sc.	Dr. P.K.Shinde	Dr.A.G.Khan
87	1992	Studies on comparative performance of inter-se and cross bred egg type mini pullets carrying sex-linked recessive dwarfing gene	M.V.Sc.	Dr. Miss Sonali Pandey	Dr.A.G.Khan
88	1993	Effect of feed restriction on early production traits of dwarf broiler breeder pullets.	M.V.Sc.	Dr. Meenakshi Sharma	Dr.A.G.Khan
89	1993	Study on the effects of feed restriction from 50-68 weeks of age on production traits of dwarf broiler breeder hens.	M.V.Sc.	Dr. S.K.Singh	Dr.A.G.Khan
90	1993	Studies on physical egg quality traits for three strains under selection and a control line of White leghorn breed.	M.V.Sc.	Dr. Kamar Jahan	Dr. R.P. Nema
91	1994	Studies on the effect of restricted feeding regime for induced rest period on performance of mini layers having sex –linked dwarfing gene.	M.V.Sc.	Dr. B.K. Lad	Dr.A.G.Khan
92	1994	Studies on dried poultry excreta on combination with enzymes and probiotics on performance traits of dwarf layers	M.V.Sc.	Dr. A.K.Ramteke	Dr.A.G.Khan
93	1994	Genotype by nutrient level interaction on juvenile growth of commercial broiler produced from dwarf broiler breeder dams.	M.V.Sc.	Dr. P.S.Mahadic	Dr.A.G.Khan
94	1994	Consequence of natural molt on production performance of lines of dwarf broiler breeder dams	M.V.Sc.	Dr. Anjay Agrawal	Dr.A.G.Khan
95	1994	Comparative studies on performance traits of two broiler genome under different nutrient levels and climatic condition.	M.V.Sc.	Dr. Neeta Dhingra	Dr.J.K.Bhardwaj
96	1994	Influence of feather Dimorphism in dwarf pullets fed diet supplemented with poultry manure, probiotics and enzymes on production	M.V.Sc.	Dr. Shyam Kali Patel	Dr.A.G.Khan
97	1996	Studies on cross dwarfed egg layer from three diversified genome	M.V.Sc.	Dr. Joyti Praveen	Dr.M.V.Poulose
98		Comparative and cross- bred mini layer under different dietary protein energy levels in summer season	M.V.Sc.	Dr. Surendra Raut	Dr.R.P.Nema
99	1997	Association of deep body temperature with production performance and nutrient levels effect on mini- layer under summer stress	M.V.Sc.	Dr. Miss Archana Agrawal	Dr.R.P.Nema
100	1997	Influence of genotype, temperature housing condition and their interaction on performance of commercial broilers from dwarf dams under summer season	M.V.Sc.	Dr. Shailendra Nema	Dr. J.K.Bhardwaj
101	1997	Influence of genotype, stocking density, protein levels and their interaction on growth, carcass performance of commercial broilers.	M.V.Sc.	Dr. Amitabh Pandey	Dr. J.K.Bhardwaj
102	1998	Comparative studies of some performance traits of two dwarf dam lines under variable dietary protein and energy levels	M.V.Sc.	Dr. T.Shriniwas Reddy	Dr.R.P.Nema
103	1998	Influence of light protein and genotype on juvenile growth of dwarf broiler breeder dam chicks	M.V.Sc.	Dr. Ajit Sharan	Dr. J.K.Bhardwaj
104	1999	Genetic variance and covariance for fertility and hatchability in dwarf broiler breeder dam lines	M.V.Sc.	Dr. Sanjay D. Yenurkar	Dr.R.P.Nema

Sl No.	Year	Title	Degree	Student	Major advisor
105	1999	Influence of dried poultry excreta enzymes probiotics and their interaction on the performance of dwarf broiler dam commercial chicks	M.V.Sc.	Dr. G.H.Parihar	Dr. J.K.Bhardwaj
106	2000	Genetic studies for dependence of performance traits on juvenile body weight of dwarf broiler breeder dams	M.V.Sc.	Dr. Amit M.Janak	Dr. J.K.Bhardwaj
107	2001	A study on the effect of feed restriction and supplementation of methionine lysine and choline on production traits of broiler breeder dam line .	M.V.Sc.	Dr. Pinky Rai	Dr.R.P.Nema
108	2002	Influence of quantitative feed restriction and protein levels on production traits of crossbred dwarf broiler dams	M.V.Sc.	Dr. Prachi Guha	Dr. J.K.Bhardwaj
109	2003	Effect of sunflower meal replacing soybean meal on performance of two dwarf dam lines	M.V.Sc.	Dr. Subrato Das	Dr. R.P. Nema
110	2003	Comparative studies on the performance traits of two dual purpose coloured birds under diversified housing system and nutritional regimes	M.V.Sc.	Dr. A.K. Giri	Dr. J.K.Bhardwaj
111	2005	Effect of replacement of Soybean meal with sunflower meal on growth performance of Dual type genome.	M.V.Sc.	Dr. Somesh Nigam	Dr. R.P. Nema
112	2007	Effect of housing, level of protein and their interaction on production performance of pure and crossbred Kadaknath birds.	M.V.Sc.	Dr. Shoaib Akhtar	Dr. R.P. Nema
113	2007	Effect of Genotype, Protein, Energy and their interaction on growth and carcass performance of multi-coloured broilers.	M.V.Sc.	Dr. S.K. Pillai	Dr. J.K.Bhardwaj
114	2007	Effect of stocking density on performance of commercial broiler fed with variable protein and Amla powder supplement diet.	M.V.Sc.	Dr. S.K. Singh	Dr. S.S. Atkare
115	2010	Effect of protein levels and supplementation of methionine and lysine on Purebred and Crossbred Kadaknath	M.V.Sc.	Dr. R. B. S. Janoriya	Dr. R. P. Nema
116	2010	Effect of various dietary protein and energy levels on performance traits of Crossbred Kadaknath hens	M.V.Sc.	Dr. Arif Riyaz Saroory	Dr. R. P. Nema
117	2010	Effect of crude fibre levels and enzyme supplementation on growth performance and carcass traits of coloured mediocre broiler.	M.V.Sc.	Dr. A.A. Dar	Dr. S.S. Atkare
118	2011	Evaluation of production performance of colour birds under diversified housing and dietary protein.	M.V.Sc.	Dr. Mr. Kiran Kumar Chourasiya	Dr. J. K. Bhardwaj
119	2011	Effect of energy, protein and probiotics supplementation on juvenile growth traits of colour birds.	M.V.Sc.	Dr. M.K. Singh	Dr. S. S. Atkare
120	2013	Effect of feeding low protein diet with and without enzyme and phytobiotics on performance of multi coloured broilers	M.V.Sc.	Dr. Patil Vaibhav Mohan Rao	Dr. J. K. Bhardwaj
121	2014	Effect of housing system, dietary energy and dried garlic powder on performance of commercial dual purpose birds.	M.V.Sc.	Dr. D. S. Rajput	Dr. R. P. Nema
122	2014	Comparison of inorganic minerals replaced with chelated minerals on growth performance of colour chicks.	M.V.Sc.	Miss. Dr. Kanak S. Rehpade	Dr. R. P. Nema
123	2017	Effect of genotype and plane of nutrition on the performance of dual type colour bird.	M.V.Sc.	Dr. Mayur H. Bohite	Dr. J. K. Bhardwaj
124	2018	Effect of dietary supplementation of Shatavari, Ashwagandha and Vitamin E on performance of colour broilers.	M.V.Sc.	Dr. Miss. Kiran Chikwa	Dr. S. S. Atkare

Sl No.	Year	Title	Degree	Student	Major advisor
125	2019	Effect of coriander seed on grower and pre-laying performance of Jabalpur colour and kadaknath birds.	M.V.Sc.	Dr. Yasir Amin Rather	Dr.R.P. Nema
126	2019	Effect of peppermint leaves and probiotics on performance of Jabalpur colour hens	M.V.Sc.	Dr. Gholve Rajesh Suryakant	Dr. S. S. Atkare
127	2019	Effect of intensive and extensive housing system on growth performance of Narmadanidhi and Crossbred Kadaknath chicken.	M.V.Sc.	Dr. Abhay Pratap Singh.	Dr. J. K. Bhardwaj
GADVASU, Ludiana					
128	1985	Inheritance of plumage color and its association with some economic traits in poultry	PhD	Iqbal Singh Bajwa	Dr. Dalbir Singh Dev
129	1990	Genetics of body composition and its relationship with body weight in broilers	MSc	Ranjit Singh	Dr. P.K. Trehan
130	1997	Genetic aspects of body weight gain in broiler chicken	MSc	Harpal Singh	Dr. Bhupinder Singh
131	2000	Inheritance of biochemical variants and their association with economic traits in chickens	M.V.Sc.	Devinder Pal Singh	Dr. JS Sandhu
132	2000	Quantitative and cytogenetic aspects of embryonic mortality and anomalies in chicken	M.V.Sc.	Alamdeep Kaur Brar	Dr. GS Brah
133	2004	Inheritance of cut-up parts and its comparative evaluation in some commercial broiler stocks	M.V.Sc.	Tanman Kaur	Dr. PK Trehan
134	2004	Inheritance of abdominal fat and its comparative evaluation in some commercial broiler stock	M.V.Sc.	Ravindra Shrivastava	Dr. Bhupinder Singh
135	2006	Genetics of support and demand tissues in meat-type chicken	M.V.Sc.	Navpreet Kaur	Dr. Bhupinder Singh
136	2008	Genetic aspects of growth and body composition in broilers	PhD	Tanman Kaur	Dr. PK Trehan
137	2009	Genetic analysis of bilateral asymmetry and disease resistance Vis-à-vis Major Histocompatibility Complex using PCR-SSP in chicken	M.V.Sc.	Mathur Pranav Dinesh	Dr. ML Chaudhary
138	2013	Genetic aspects of growth, immunological and physiological traits in broiler chickens	PhD	Parminder Singh	Dr. IS Bajwa
139	2015	Evaluation and comparison of reproductive, carcass, growth and immune responsiveness traits in divergent stocks of chicken.	M.V.Sc.	Prajwalita Pathak	Dr P P Dubey
140	2018	Genetic Evaluation and effect of IGF-I gene polymorphism with performance traits in growth line of two way cross broiler variety	M.V.Sc.	Swayamprabha Naik	Dr. SK Dash
141	2019	Evaluation of Antioxidant potential of Tomato and Orange juice on extended poultry semen preserved with egg yolk and coconut water diluents to improve selection intensity	PhD	Balogun Adedeji Suleimon	Dr. Raman Narang
142	2020	Association of IGF-1 expression with growth parameters in IBL-80 and native cross poultry varieties under heat stress	M.V.Sc.	Kedimetla Sneha	Dr. SK Dash
143	2021	Discriminant analysis and study of polymorphism in myostatin (GDF-8) gene in native poultry	M.V.Sc.	Sumeet Patil	Dr. SK Dash
144	2011	Genetic Characterization of native chicken of Himachal Pradesh using Molecular Markers	M.V.Sc.	Dr Jagish Kour Reen	Dr. Sanjeet Katoch
145	2018	Comparative study of Blood Profile of Native Chicken with Dahlem Red and Their Crosses	M.V.Sc.	Dr. Smriti Saklani	Dr. Geetanjali Singh
146	2020	Biochemical and Physical Characterization of Eggs of Himsamridhi Breed and its Comparison with Dahlem Red	M.V.Sc.	Dr. Suruchi Sharma	Dr. Geetanjali Singh
147	2022	Incidence of antimicrobial resistant pathogenic *Escherichia coli* in poultry reared under intensive and backyard production systems	M.V.Sc.	Dr. Maansi Soodan	Dr. Sidharath Dev

Scientific manpower

Project coordinators

Name	Period	
	From	To
Dr.S.C.Mohapatra	1.4.1971	23.8.1994
Dr.V.R.Sadgopan	24.8.1994	11.9.1995
Dr.V.Ayyagari	12.9.1995	30.6.1999
Dr.G.Shyam Sundar	1.7.1999	30.6.2000
Dr.R.P.Sharma	1.7.2000	31.12.2010
Dr.R.N.Chatterjee	1.1.2011	Till date

Incharge, AICRP Cell

Name	Period	
	From	To
Dr.S.C.Mohapatra	1971	1994
Dr.V.Ayyagari	1995	1999
Dr.R.C.Hazary	1999	2004
Dr.M.V.L.N.Raju	2004	2004
Dr.M.Naranjan	2004	2005
Dr.R.N.Chatterjee	2005	2010
Dr.M.K.Padhi	2011	2013
Dr.M.Niranjan	2013	2017
Dr.U.Rajkumar	2017	Till date

Scientific Staff worked in the project

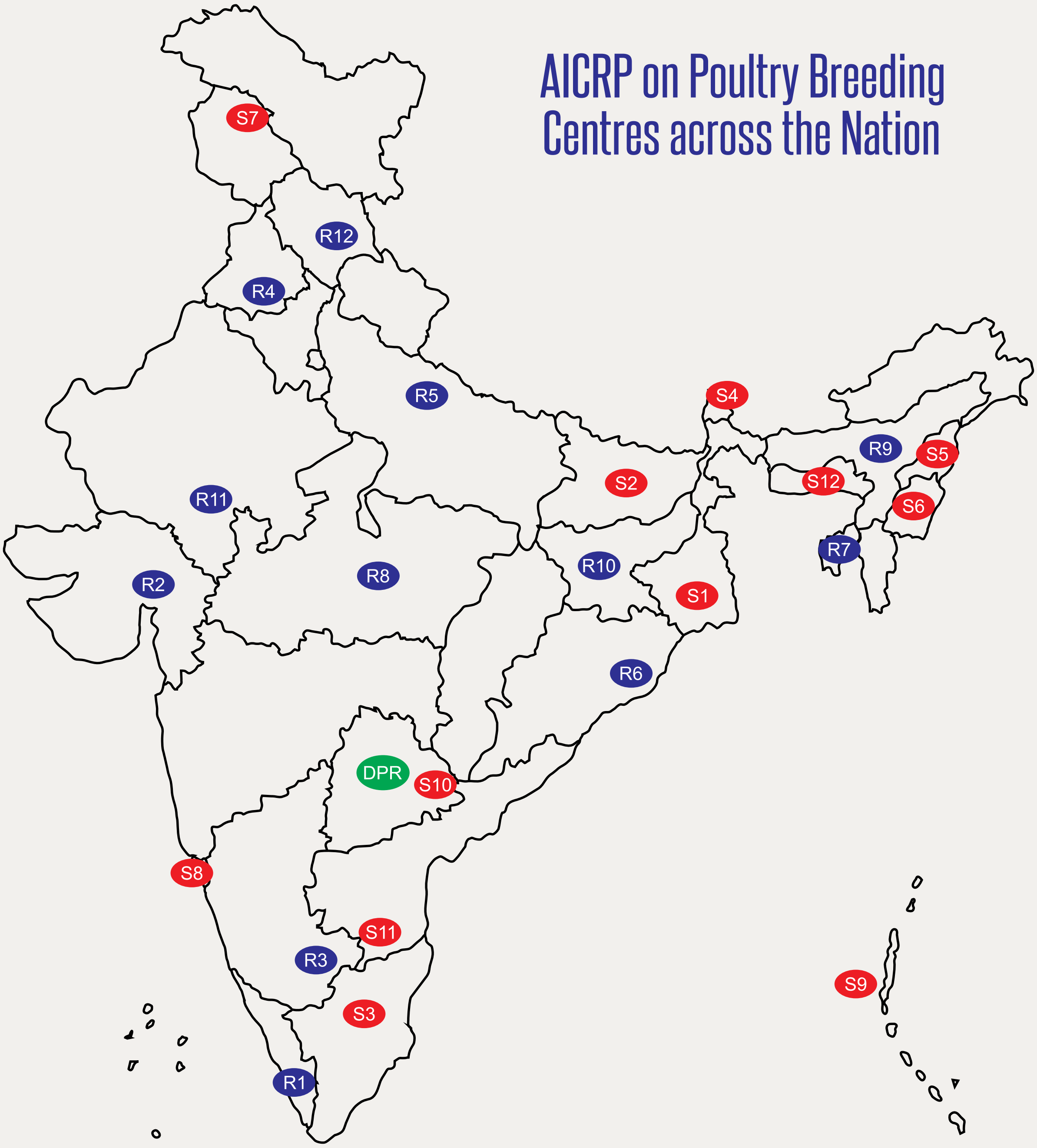
Name	Period	
	From	To
1. KVASU, Mannuthy		
Dr. C.K. Venugopalan	22-02-1977	30-11-1981
Dr. A.K.K. Unni	01-12-1981	1984
Dr. A. Ramakrishnan	1984	31-10-1985
Dr. A.K.K. Unni	01-11-1985	01-05-1997
Dr. A. Jalaludeen	02-05-1997	26-07-1998
Dr. K. Narayanankutty	27-07-1998	14-06-2012
Dr. P. Anitha	15-06-2012	25-05-2016
Dr. Binoj Chacko	26-05-2016	31-05-2019
Dr. Beena C. Joseph	01-06-2019	31-10-2021
Dr. S. Sankaralingam	16-11-2021	Till date
2. AAU, Anand		
Dr. R. K. Shukhla	01-04-1979	31-08-1995
Dr. Kuldeep Khannna	01-09-1995	17-12-1995
Dr. J. M. Patel	18-12-1995	28-02-1997
Dr. Kuldeep Khanna	01-03-1997	30-11-2001
Dr. P. H. Vataliya	01-12-2001	23-10-2002
Dr. Kuldeep Khanna	24-10-2002	31-03-2011
Dr. F. P. Savaliya	01-04-2011	till date
3. KVAFSU, Bengalure		
Dr. B.S.Ramappa	01-04-1971	31-07-1989
Dr. G.R.Lokanath	01-08-1989	31-12-1998
Dr. K.S.Prathap kumar	01-01-1999	21-04-1999
Dr. H.N.Narasimha Murthy	22-04-1999	22-04-2013
Dr.B.Umakantha	23-04-2013	25-07-2013
Dr. C.S.Nagaraja	26-07-2013	24-11-2021
Dr.Jayanaik	25-11-2021	31.1.2024

Name	Period	
	From	To
Dr.Krishnamurthy.T.N	1.2.2024	Till date
4. GADVASU, Ludhiana		
Dr. Bhupinder Singh	October, 1977	January, 2007
Dr. I.S. Bajwa	February, 2007	April, 2013
Dr. H.S. Sandhu	May, 2013	December, 2014
Dr. Shakti Kant Dash	January, 2015	October, 2022
Dr. Saroj Kumar Sahoo	November, 2022	Till date
5. OUAT, Bhubaneswar		
Dr. S.C. Mishra	01.09.1991-	31.10.2008
Dr. P. K. Mishra	01.11.2008-	27.02.2011
Dr. N.C. Behura	28.02.2011	28.02.2013
Dr. S.K. Dash	01.03.2013	31.03.2013
Dr. P.K. Mishra	01.04.2013	28.02.2015
Dr. N.C. Behura	01.03.2015	30.08.2020
Dr. S.K. Dash	31.08.2020-	29.11.2022
Dr. L. Samal	30.11.2022	till date
6. CARI, Izatnagar (Broiler)		
Dr. S.C. Mohapatra	1971	1985
Dr. R. P. Sharma	1985	1995
Dr. B. P. Singh	1995	2000
Dr. A. K. Dev Roy	1995	2000
Dr. V. K. Saxena	2000	2005
Dr. Simmi Tomar	2005	2006
Dr. V. K. Saxena	2006	2008
Dr. S. K. Bhanja	2008 (for 6 Months)	

Name	Period	
	From	To
Dr. V. K. Saxena	2008	2019
Dr. Simmi Tomar	2019	Till date
7. NDVSU, Jabalpur		
Dr. A.G. Khan	1971	1996
Dr. M.V. Poulose	1996	1997
Dr. J.K. Bhardwaj	1997	2020
Dr. S.S. Atkare	2020	2022
Dr. Girraj Goyal	2022	2023
Dr. Vaishali Khare	2023	Till date
8. CHKPVV, Palampur		
Dr Sanjeet Katoch	01.03.2009	30.04.2014
Dr Y P Thakur	30.04.2014	31.10.2020
Dr Varun Sankhyan	31.10.2020	continuing
9. BAU, Ranchi		
Dr. Sushil Prasad	23.3.2009	Continuing
MPUAT, Udiapur		
Dr.S.P.Tailor	July 2009	February 2016
Dr. O.P.Pathodiya	February 2016	July 2016
Dr.Sidhartha Mishra	July 2016	Till date
10. ICAR RC, Tripura Centre		
Dr.M.Niranjan		
Dr.S.K. Mallik		

Name	Period	
	From	To
Dr. Vinay Singh		
AAU, Guwahati		
Dr. Niranjan Kalita	18.05.2009	31.01.2023
Dr. Mihir Sarma	01.02.2023	Till Date
11. CARI, Izatnagar (layer)		
Dr. S.C. Mohapatra	1971	1985
Dr. D.C. Johari	1985	2000
Dr. R. C. Hazary	2002	2002
Dr. M. C. Katariya	2002	2005
Dr. R.K. S. Bais	2005	2006
Dr. M. C. Katariya	2006	2008
Dr. Sanjeev Kumar	2008	-
12. SVVU, Hyderabad		
Dr. D.Subbarayudu	26.10.1974	16.11.1979
Dr. P.L.N. Sarma	17.11.1979	05.08.1986
Dr. D.Subbarayudu	06.08.1986	09.08.1988
Dr. P.L.N. Sarma	10.08.1988	30.06.1990
Dr. K. Chaithanya	09.08.1990	18.09.1991
Dr. A.Srirama Murthy	18.09.1991	31.10.1999
Dr.P.Mahipal Reddy	01.04.1999	31.12.2005
Dr. Venkataramaiah	30.09.2005	23.08.2006
Dr. S. Qudrathullah	15.12.2006	23.08.2007
Dr. S.T. Viroji Rao	24.08.2007	-

AICRP on Poultry Breeding Centres across the Nation



ICAR - DPR

AICRP Centres (old)

R1	KVASU, Mannuthy
R2	AAU, Anand
R3	KVAFSU,Bengaluru
R4	GADVASU, Ludhiana
R5	ICAR-CARI, Izatnagar
R6	OUAT, Bhubaneswar
R7	ICAR-RCNEH, Agartala
R8	NDVSU, Jabalpur
R9	AAU, Guwahati
R10	BAU, Ranchi
R11	MPUAT, Udaipur
R12	CSKHPKVV, Palampur

AICRP Centres (2023 onwards)
Former PSP Centres

S1	WBUAFS, Kolkata
S2	BASU, Patna
S3	TANUVAS, Hosur
S4	ICAR-RCNEH, Gangtok
S5	ICAR-RCNEH, Jharnapani
S6	ICAR-RCNEH, Imphal
S7	SKUAST, Srinagar
S8	ICAR-CCARI, Goa
S9	ICAR-CIARI, Port Blair
S10	PVNRTVU, Warangal
S11	SVVU, Tirupati
S12	ICAR-RC for NEHR, Barapani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प्रशासनिक एवं
प्रयोगशाला भवन
ADMINISTRATIVE CUM
LABORATORY BUILDING

ISBN No. 978-81-971265-5-0

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